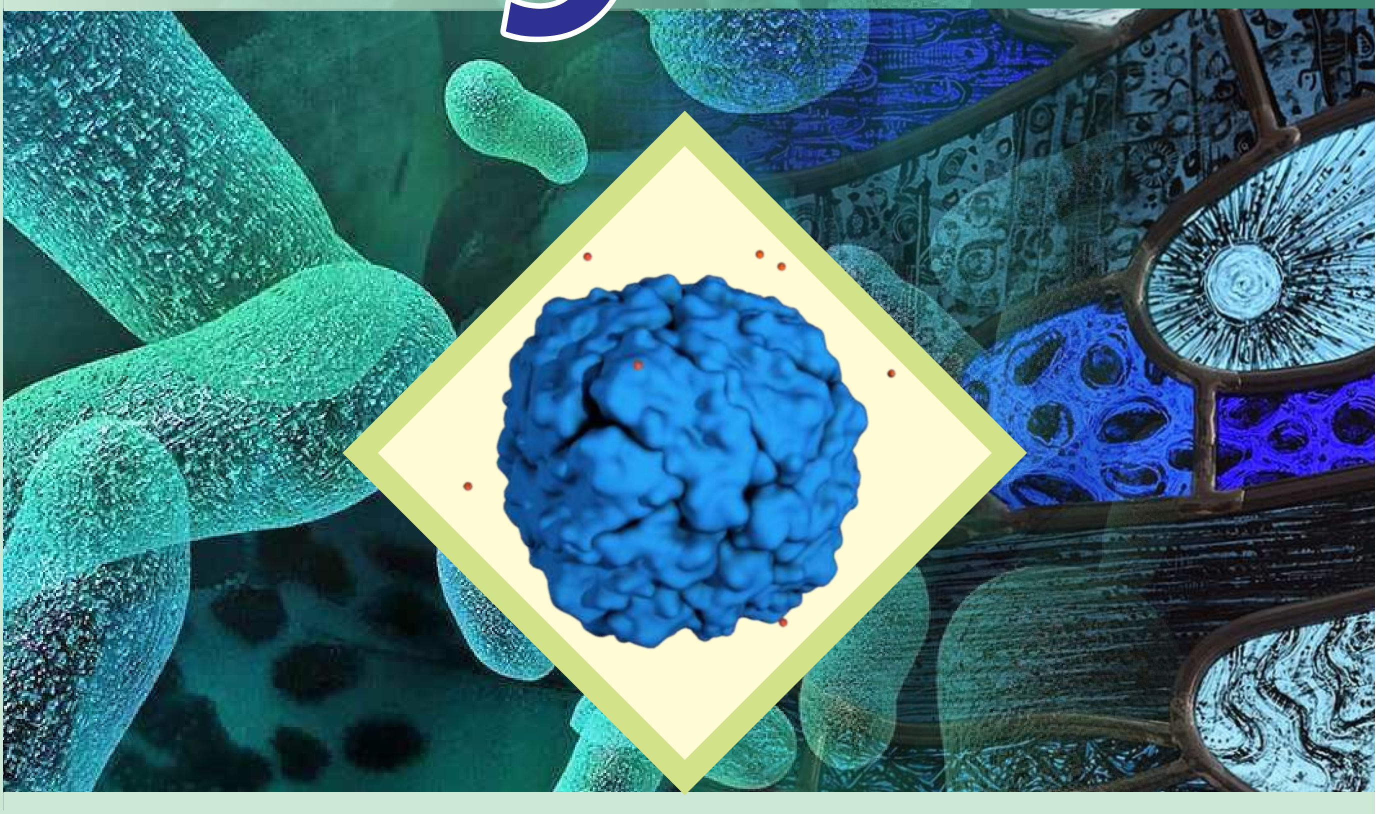
THE TEXTBOOK OF

BIOLOGY

For Class 9

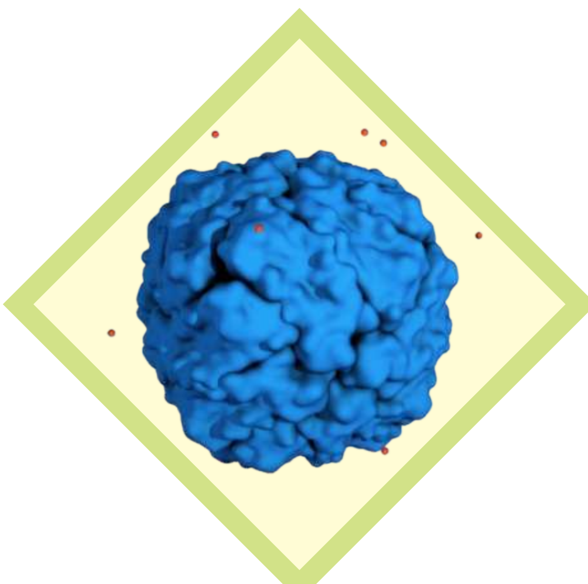


Sindh Textbook Board, Jamshoro

THE TEXTBOOK OF BIOLOGY FOR CLASS 9

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For Class 9



Sindh Textbook Board, Jamshoro

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CONTENTS

PREFACE

The century we have stepped in, is the century of Biology. The modern disciplines Biology are strongly influencing not only all the branches of science but each and every aspect human life.

To keep the students. abreast with the recent knowledge, it is a must that the curricula, at all the levels, be updated regularly by introducing the rapid and multidirectional development taking place in all the branches of Biology.

The recent book of Biology for class IX has been written in this preview and in accordance with the revised curriculum prepared by Ministry of Education, Govt of Pakistan, Islamabad reviewed by independent team of Bureau of Curriculum, Jamshoro sindh. Keeping in view of the importance of Biology, the topics have been revised and re-written according to the need of the time.

Since long Biology was teaching only in IX class, the text book was consits of 19 chapters which was unable to complete in working hours. it has been decided now the Biology syllabus will be divided into portions, one should teach in 9th class and other will teach 10th class. So this book is consist of 9 chapters which have been thoroughly revised and re-written to meet the requirement of the curriculum. Special emphasis has also been paid to the applied aspect including the biological problems of daily life. Attention has also been focused on the causes and preventive measures of the common disorders of the human body. Being agriculture country, the agriculture aspects and problems of country are also discussed.

Among the new editions are the introductory paragraphs, information boxes, summaries and a variety of extensive exercises which I think will not only develop the interest but also add a lot to the ut

ility of the book.

The Sind Textbook Board has taken great pains and incurred expenditure in publishing this book inspite to its limitations. A textbook is indeed not the last word and there is always room for improvement. While the authors have tried their level best to make the most suitable presentation, both in terms of concept and treatment, there may still have some deficiencies and omissions. Learned teachers and worthy students are, therefore, requested to be kind enough to point out the short comings of the text or diagrams and to communicate their suggestions and objections for the improvement of the next edition of this book.

In the end, I am thankful to our learned authors, editors and specialist of Board for their relentless service rendered for the cause of education.

Chairman
Sindh Textbook Board

INTRODUCTION TO BIOLOGY

Chapter 1

Major Concept

In this Unit you will learn:

- Introduction of Biology
  - Definition of Biology
  - Divisions and Branches of Biology
  - Relation of Biology with other sciences
  - Quran Instructs to reveal the study of life
- The Levels of Organization



INTRODUCTION

Biology is a branch of natural sciences which deals with the study of living beings. It provides the knowledge about living organisms which differ from each other in shape, size, composition etc. The word biology comes from Greek language "***Bios***" meaning "live" and "***Logos***" meaning "thought or reasoning". Thus biology meaning study of life.

What is life?

Life cannot be defined properly, but on the basis of life processes, it can be identified through following functions of living organisms.

- Digestion
- Respiration
- Metabolism
- Movement
- Growth
- Development
- Excretion
- Irritability
- Reproduction

1.1 Divisions and branches of Biology

1. Division of Biology:

There are three major divisions of biology:

(i) Zoology:

The word Zoology is derived from Greek language, "**Zoon**" meaning animals and Logos meaning "study or knowledge". It deals with the study of animals.

(ii) Botany:

The word Botany is taken from Greek language, "**Butane**" meaning plants and Logus meaning "study or knowledge". It deals with the study of plants.

(iii) Microbiology:

It deals with the study of microscopic organisms such as Bacteria etc, which can be seen only with the help of microscope.

2. Branches of Biology:

Modern biology deals with the structure, function and many other descriptions of living things. Advance research during the 20th Century has led to the division of biology into specialized branches. Some important branches are defined below:

(i) **Morphology** (Gr. morph; form, logos; discourse)**:** The study of external form and structure of organisms.

(ii) **Anatomy** (Gr. ana; part/up, tome; cutting)**:** The study of internal parts of body of living organisms by cutting them open.

(iii) **Cell biology** (L. cells, compartment, Gk. Bios= life; logos; discourse)**:** The study of cell and its organelle.

(iv) **Histology** (Gr. histos: tissue; logos, discourse)**:** The study of structure of tissues of plant and animals.

(v) **Physiology** (Gr. physis; nature, logos, discourse)**:** The study about functions of living organisms.

(vi) **Taxonomy** (Gr. taxis, arrangement, nomos: name)**:** The study of the rules, principles, grouping and naming the living organisms.

(vii) **Genetics** (Gr. genesis; descent, origin)**:** The study of heredity, that is transferring of characters from parents to offspring.

(viii) **Developmental biology** (Gr. embryon; embryo, logos, discourse)**:** The study of formation and development of embryo.

(ix) **Environmental biology:** The study of relationship between living organisms and non-living factors of environment and their effects on each other.

(x) **Paleontology** (Gr. palaios; ancient, ontos; being, logos: discourse)**:** The study of remote past organic life, with the help of fossils.

(xi) **Biotechnology:** The study about techniques for manipulination of gene to bring the changes in structure and location of genes to achieve desireable characters is called biotechnology.

(xii) **Socio-biology** (L. sociare; to associate,)**:** The study of social behavior of living organisms. i.e interaction between themselves.

(xiii) **Parasitology** (Gr. para; up)**:** The study of parasites.

(xiv) **Pharmacology** (Gr. pharmakon, drug;). The study about action of drugs.

(xv) **Molecular biology:** The study of organic molecules which constitute cell and its organelles.

1.1.1 Relationship of biology with other sciences:

Biology is a multidimensional subject and linked with other sciences. For example, the movement of animals follows the laws of motion in physics. Biology is considered as interdisciplinary science, which is related with other sciences. Some of these are mentioned below:

Biophysics:

It is a branch of physics, in which laws and techniques of physics are applied to explain the processes of life. The radiophysics branch where radioactive isotopes are used to trace the translocation of different materials within the organisms. Radio-labeling and carbon-dating also show some uses of radioactive isotopes in determining the age of fossils, uses of sound waves as ultrasound and laser technology show relation of physics with biology.

Biomathematics/Biometry:

The branch of mathematics which collects data of living organisms. It plays very important role in research.

Biochemistry:

It is branch of biology which deals with the study of molecules which form living organisms or cell and requires authentic knowledge about biology and chemistry to explain the synthesis of biomolecules and function of different molecules in the body of an organism.

Biogeography:

It deals with the distribution of different living organisms in different geographical regions of the world. Many living organisms are restricted to particular geographical regions due to environmental conditions.

Bio-economics:

This deals with the economically important organisms involved in production, e.g meat production, etc. are calculated for cost value and profit value.

1.1.2 Careers in biology:

The career of student is subject to obtain a degree. The students, who have chosen the biology, they can plan to adopt some as a career in following fields:

Medicine and Surgery:

Medicine deals with diagnosis and treatment of diseases and surgery deals with repair, replacement or removal the affected organ.

Agriculture:

This deals with production of varieties of crops, fruit, vegetables, dairy products, etc. Pakistan being an agricultural country, it can play very important role.

Horticulture:

This is also part of agriculture, in which work is carried out for the development of new varieties of plants and their products.

Forestry:

Forests are the source of biodiversity of plants and animals of many kinds which live there. It is important in development of new forests as well as preservation of existing ones.

Farming:

In this profession, the development of different kinds of farms takes place, such as fish farm, cattle farm, poultry farm, etc. New technologies are used for the production of animals as source of meat and milk, leather, wool, etc.

Animal husbandry:

This profession is part of agriculture science. It deals with the care and breeding of animals which are beneficial for man.

Fisheries:

This profession deals with the increased quantity and quality of fish production. Fish is one of the best source of protein.

Biotechnology:

This is very important and sensitive profession. It deals with manipulation of gene to produce valuable chemical products, such as insulin, growth hormones, interferon, etc from bacteria as well as others.

1.1.3 Quran and Biology:

The Almighty Allah has conveyed a great knowledge about the origin and characteristics of animals and plants through our Holy Book, the Quran. A few of Ayah are quoted as under:

Allay Says;

وَجَعَلْنَا مِنَ الْمَآءِ كُلَّ شَيْءٍ حَيٍّ ؕ

"We made every living thing from water".
(Surah: Ambia, Verse: 30)

وَاللّٰهُ خَلَقَ كُلَّ دَآبَّةٍ مِّنْ مَّآءٍ ۚ فَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰى بَطْنِهٖ ۚ وَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰى رِجْلَيْنِ ۚ
وَمِنْهُمْ مَّنْ يَّمْشِيْ عَلٰٓى اَرْبَعٍ ؕ يَخْلُقُ اللّٰهُ مَا يَشَآءُ ؕ اِنَّ اللّٰهَ عَلٰى كُلِّ شَيْءٍ قَدِيْرٌ ○

"And Allah has created every animal from water of them there are some that creep on their bellies, some that walk on two legs; and some that walk on four. Allah creates what He will Lo! Allah is able to do all things."
(Surah Al-Nur, Ayah-45)

Here water is symbolized with the protoplasm as the basis of life and the vital power of protoplasm seems to depend on the constant presence of water.

وَفِي الْاَرْضِ قِطَعٌ مُّتَجٰوِرٰتٌ وَّجَنّٰتٌ مِّنْ اَعْنَابٍ وَّزَرْعٌ وَّنَخِيْلٌ
صِنْوَانٌ وَّغَيْرُ صِنْوَانٍ يُّسْقٰى بِمَآءٍ وَّاحِدٍ وَنُفَضِّلُ بَعْضَهَا
عَلٰى بَعْضٍ فِي الْاُكُلِ ۚ اِنَّ فِيْ ذٰلِكَ لَاٰيٰتٍ لِّقَوْمٍ يَّعْقِلُوْنَ ۝٤

"And in the earth are neighboring tracks, vineyards and ploughed lands, and date-palms, like and unlike which are watered with one water. And we have made some of them to excel others in fruit. Lo! Here in verily are portents for people who have sense."

(Surah: Al-Ra'd, Ayah: 4)

Here Allah has revealed some facts about plant growth and development.

1.1.4 Contribution of Muslim Scientists:

The Muslim scientists have played great role in the development of biological science. They began experiments and observations from the first Century of Hijra. Following are some details about the important Muslim scientists, who made significant contribution towards the development of biology.

1. Jabir Bin Hayan (722-817 A.D):

He was born in Iran. He worked in the field of chemistry but he also wrote a number of books on plants and animals. "Al-Nabatiat" and "Al-Haywan" are his two famous books on plants and animals, respectively.

2. Abdul Malik Asmai (741-828 A.D):

He was great zoologist and wrote many books on animals like "Al-Kheil" on horse, "Al-Ibil" on camels, "Al-Shat" on sheep, "Al-Wahoosh" on wild animals and "Khalqul Insan" on the different parts of human body and their functions.

3. Bu Ali Sina (980-1037 A.D):

He was greatest of all the Muslim scientists and considered as the founder of medicine. He is called as Avicenna in the west. He identified many diseases like tuberculosis, meningitis and other such inflammations. He also worked in the field of mathematics, astronomy, physics, paleontology and music. He wrote book like "Al-Qanoon" and "Fil Tib Al-Shafa".

1.2 THE LEVEL OF ORGANIZATION

The levels of organization in living world are based on chemical foundation. All the living organisms are made up of cells and the protoplasm of cell is the physical as well as chemical basis of life. These levels are as follows:

1. Atomic level of organization:

All the matter is made up of elements, which is composed of atom (a: not, form: cut). Each atom is made up of sub-atomic particles, such as electrons, protons and neutrons.

In nature, there are more than 100 kinds of elements and among these 16 elements are called as bio-elements, which are vital for life. Only six elements such as C, H, O, N, S and P are called basic elements of life.

2. Molecular level of organization:

Molecules are formed by the binding of atoms. These organic molecules of cells are called as bio-molecules. These are constructed in great variety and complexity. They are classified as micro-molecules and macro-molecules.

Glucose, amino acid and fatty acids are micro-molecules, where as carbohydrates, proteins and lipids are macro-molecules. The units of micro-molecules combine together to form macro-molecules.

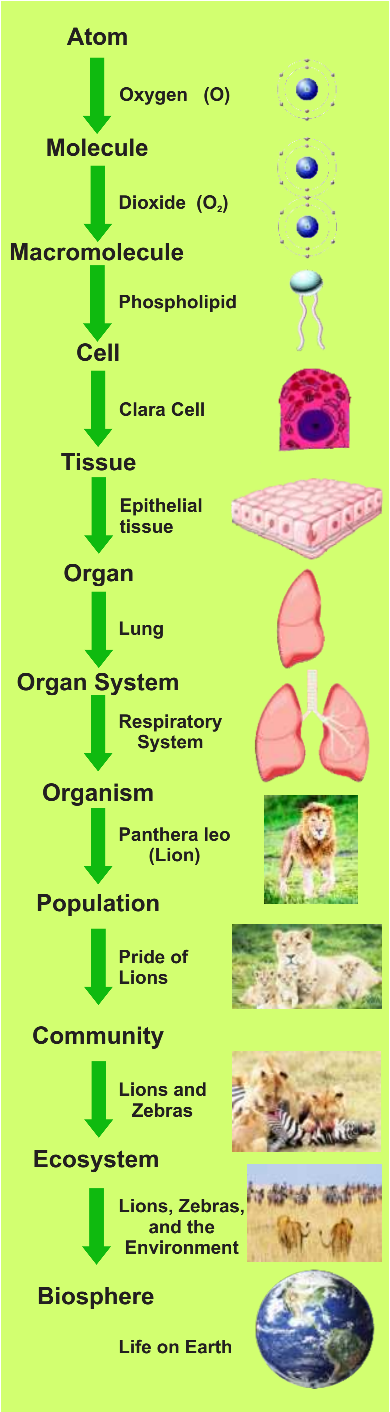


Fig: 1.1 Levels of organization

3. Cellular level of organization:

The biomolecules when work together in the form of suspension, It is called **Protoplasm**. Protoplasm is the combination of organic and specific inorganic substances. When protoplasm work in the form of a unit, this is called **Cell**. Cell is the basic unit of living organisms. When similar type of cells organize together in a group, called tissues. The different types of tissues arranged in a particular manner to work together are called **Organs**.

Organs of different types work in a co-ordinated manner to perform a function is called **Organ-system**. When different organ-system function in co-ordination in as a unit, they form a body or **Multicellular Organism**.

4. Taxonomic level:

There is another level of organization which is related with living organisms. The **Species** is the smallest unit of taxonomic level of organization, which includes morphologically similar living organisms which inter-breed and produce fertile offspring.

5. Population level:

All the members of a species, living in specific habitat are called **Population**. A group of parrots living on tree, is called parrot population.

6. Community level:

The members of different species living in specific habitat are called as **Community**. A group of different kind of birds, living on tree, is called as bird community.

7. Ecological system:

Communities always depends upon their non-living environment in a reciprocal interaction for their survival. For example oxygen for respiration is obtained from environment and in turn given out CO_2. This interaction is called Ecosystem or Ecological system.

8. Biosphere level:

The part of earth where life exists is called biosphere. It consists of different kinds of eco systems.

1.2.1 Unicellular Organizations:

All single cell organisms carry out all activities of life. They digest the food, respire, excrete, move etc on the cellular base by simple methods. Bacteria, Amoeba, Paramecium and Euglena are common examples of unicellular organisms.

1.2.2 Colonial Organization:

Many unicellular organisms live together by forming colonies but do not have any division of labor among them. In colonial type of cellular organization, each unicellular organism lives its own life, they are not dependent on each other and never form any multicellular structure. *Volvox* is a green alga (as shown in figure 1.4), is an example of colonial form of organization.

1.2.3 Multicellular Organization:

The organism formed by many cells is called as multicellular organism. Frog and mustard plant are examples of multicellular organization.

Mustard plant:

Brassica campestris is commonly known as mustard plant and locally it is called "**Sarsoon**". It is multicellular and cultivated in winter season. The leaves of this plant are used as vegetable while seeds are used for oil extraction. The length of this plant is 1 to 1.5 meter. This plant has two parts, the vegetative part, which consists of root, stem and leaves and reproductive part which consists of flowers. Each flower is yellowish in color and produce seeds.

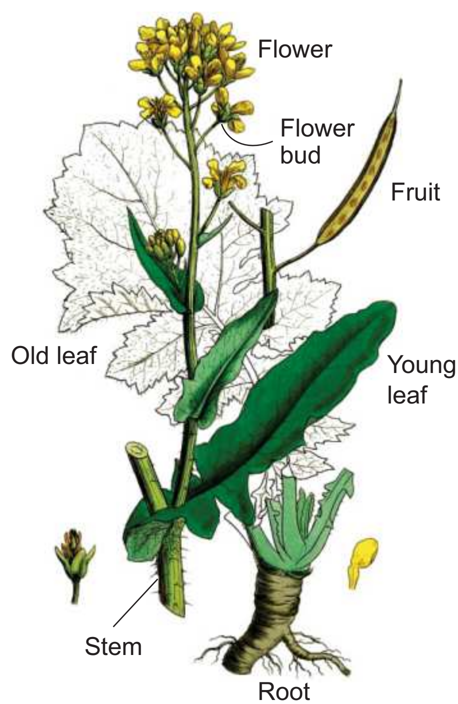


Fig: 1.2 Brassica campestris

Frog:



Fig: 1.3 Frog

Rana tigrina is the scientific name of spotted frog found commonly in our region. It is multicellular animal. It lives in both water as well as on land. Its body is divided into head and trunk. There is no neck. Its body is made of organ system with different organs.

All organs are made of different tissues such as epithelial, glandular, muscular, nervous etc. Frog lives near ditches, pools, ponds, stagnant stream and slow moving rivers. It feeds on small insects.

Activity: Identification of organs and organ-system in dissected frog:

Material Required:

- Preserved frog
- dissection box
- dissecting tray
- pins

Procedure:

Place the preserved frog on a dissecting tray on its back, as all vertebrates are dissected ventrally, pin down the fore limbs and hind limbs. Take scissor to cut the abdomen ventrally, from cloaca to the mouth. Again cut down the skin of limbs from each side and pin down. Expose the visceral organs clearly and make observation with the help of diagram. Locate the organs and identify them as below:

Table showing different organs with the relative organ system.

Organs	Organ System
Mouth, buccal cavity, Pharynx, Esophagus, stomach, small intestine, large intestine, cloaca, liver, gall bladder,pancreas.	Digestive system
Heart, atria ventricle, Aortae, Vena cavae	Circulatory system
Lungs, trachea, nostrils	Respiratory system
Kidneys, Ureter, Urinary Bladder	Excretory system
Testes, vasa efferentia, Ovaries, Oviduct, Ovisac	Reproductive system
Brain, Spinal Cord, Nerves	Nervous system

Draw the labelled diagram of dissected frog.



Fig: 1.4 Dissected frog

Amoeba:

Amoeba is a unicellular organism found in the mud of shallow pond, pools and at any stagnant water. Its size is about 0.25mm. Amoeba has a irregular shape. It has a cell membrane which helps in movement of molecules and protects cytoplasm. The outer part of cytoplasm is clear and transparent, called ectoplasm (gel) and inner part is called endoplasm (sol). The cytoplasm contains nucleus, food vacuoles, mitochondria etc. Amoeba moves by false foot, called pseudopodia.

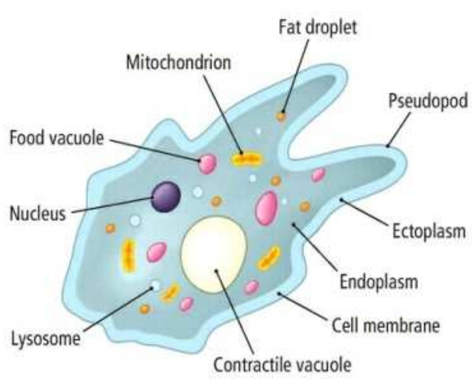


Fig: 1.5 Amoeba

Volvox:

Volvox is a polyphyletic (many ancestors) genus of chlorophyte green algae in the family Volvocaceae. It forms spherical colonies of upto 50,000 cells. They live in a variety of fresh water habitats and were first reported by ***Antonie Van Leeuwen Hoek*** in 1700.

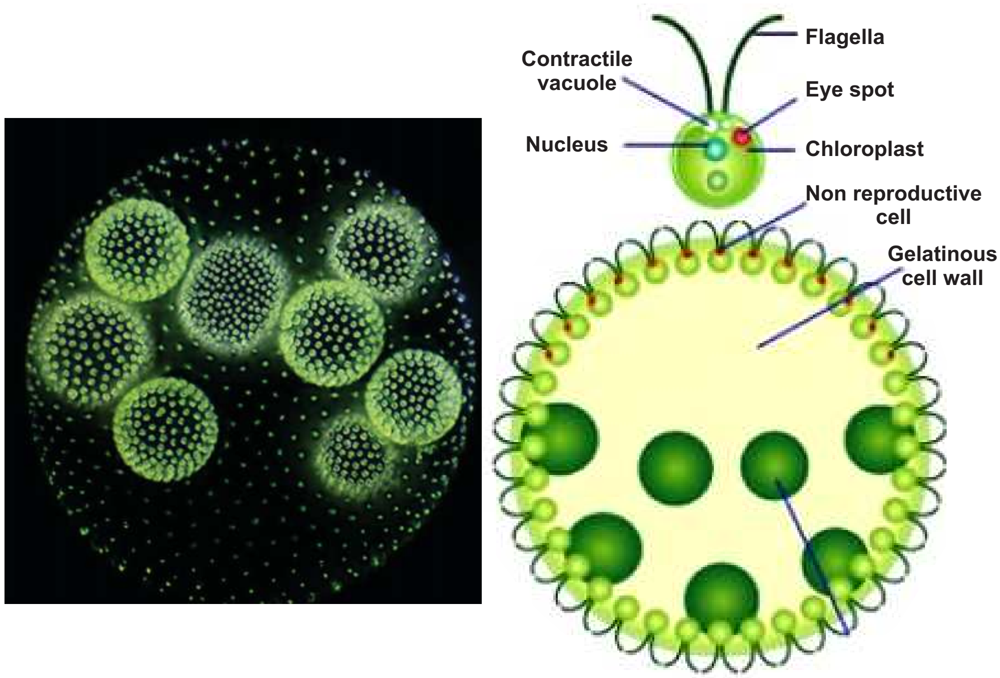


Fig: 1.6 Volvox colony

Volvox once called algae that live together in a colony. Each Volvox cell has two flagella. The flagella beat together to roll the body in water. Volvox cells have chlorophyll and make their own food by photosynthesis. These photosynthesis organisms are an important part of many aquatic eco system. Volvox are not harmful to humans because they do not produce any toxic substance.

Summary

- Biology deals with the study of living beings.
- Life can be identified on the basis of certain processes.
- Biology can be divided in three major divisions.
- Biology is linked with other sciences such as Physics, Chemistry, Mathematics, etc.
- Economically, Biology is very important for food, medicines, forestry and farming etc.
- The Almighty Allah has conveyed a great knowledge about origin and characteristics of living beings in the Holy Quran.
- Muslim Scientists have played great role in the development of biological science.
- Various levels of organization have been identified in the living world.
- Protoplasm is the chemical basis of life.
- Smallest unit of protoplasm is cell.
- Organisms could be unicellular or multicellular.
- Brassica campastris is commonly known as Mustard (Sarsoon) plant.
- Rana tigrina is biological name of frog.
- Amoeba is unicellular organism.
- Volox belong polyphylectic group of algae. It lives in colonial form.

Review Questions

1. Encircle the correct answer:

(i) A localized group of organisms that belong to the same species is called a:

(a) Biosphere (b) Community

(c) Ecosystem (d) Population

(ii) Increased quantity and quality of fish production:

(a) Fisheries (b) Farming

(c) Animal husbandry (d) Forestry

(iii) Study of remote past organic life, with the help of fossils.

(a) Entomology (b) Paleontology

(c) Taxonomy (d) Histology

(iv) Laws and techniques of physics are applied to explain the living processes of life.

(a) Biometry (b) Biostatistics

(c) Biophysics (d) Bio-economics

(v) Choose the incorrect statement:

(a) Six elements such as C, H, O, N, S and P are called basic elements of life.

(b) Foundation of life based on chemicals.

(c) Members of different species form population.

(d) Part of earth where life exists is called biosphere

(vi) Science of diagnosis and treatment of diseases.

(a) Agriculture (b) Medicine

(c) Surgery (d) Both B and C

(vii) Similar cells combine together to form:

a) Organs (b) System

(c) Tissue (d) Body

(viii) Scientific name of frog is:

(a) Palaeon (b) Rana tigrina

(c) Periplaneta (d) Pheretima

(ix) Select the correct sequence of biological organization

(a) Atom → Cell → Tissue → Molecule → Organ

(b) Atom → Tissue → Cell → Molecule → Organ

(c) Atom → Molecule → Cell → Tissue → Organ

(d) Atom → Cell → Molecule →Tissue → Organ

(x) *Volvox* is a polyphyletic genus of

(a) Green algae (b) Red algae

(c) Brown algae (d) None of these

2. Fill in the blanks

(i) Techniques for manipulation of gene to achieve desirable characters are called____________.

(ii) Distribution of different living organisms in different regions of the world____________.

(iii) Part of agriculture for the development of new varieties of plant, and their fruit is ____________.

(iv) Bio elements considered as vital for life are __________ in members.

(v) Members of different species living in specific habitat are called __________.

(vi) The Muslim scientists who identified many diseases like tuberculosis, meningitis and other such inflammations was _______.

(vii) Part of earth where life exists is called______.

(viii) Foundation of life based on ________.

(ix) Fish is one of the best source of________.

(x) Radio labeling and carbon dating also show some uses of radioactive isotopes in determining the ________ of fossils.

3. Define the following terms

(i) Anatomy (ii) Histology (iii) Immunology
(iv) Pharmacology (v) Entomology (vi) Biometry
(vii) Biogeography (viii) Surgery (ix) Animal husbandry
(x) Bioelements

4. Distinguish between the following in tabulated form

(i) Colonial organization and multicellular organization
(ii) Agriculture and horticulture

5. Write short answers of following questions.

(i) Why subject biology is named as multidimensional subject?
(ii) How farming profession helps mankind?
(iii) Why species is called as smallest taxonomic level?
(iv) How population is different from community?
(v) How new varieties of plant are produced?
(vi) Draw a labeled diagram of frog's digestive system.

6. Write detailed answers of the following questions.

(i) Describe the role of Muslim scientists in the field of biology.
(ii) Describe the relationships of biology to other sciences.
(iii) Describe the level of organization.

SOLVING A BIOLOGICAL PROBLEM

Chapter 2

Major Concept

In this Unit you will learn:

- Biological Method
  - Scientific problem, Hypotheses, Deductions and Experiments
  - Theory, Law and Principle
  - Data organization and Data analysis
  - Mathematics as an integral part of the Scientific Process



Science is the systematic study of nature and how it affects us and the environment. It is a body of knowledge that is constantly changing through the use of better and more accurate tools for investigation. At the core of biology and other sciences lies a problem-solving approach called the scientific method.

The scientific method is a series of steps followed by scientific investigators to answer specific questions about the natural world.

2.1 BIOLOGICAL METHOD

As you know that biology is the branch of science concerned with the study of living things, or organisms. The system of advancing knowledge by formulating a question, collecting data about it through observation and experiment, and testing a hypothetical answer about living things is called biological method.

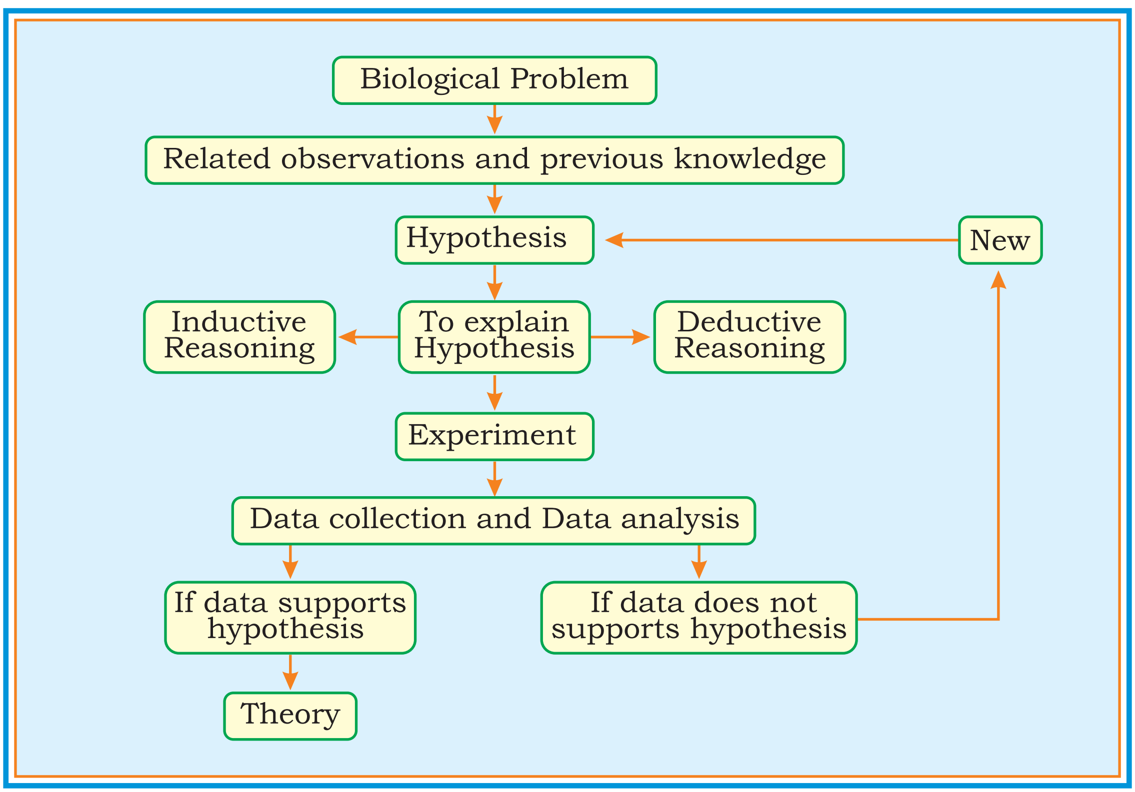


Figure 2.1 The steps involved in a biological method

2.1.1 Biological problem, Hypothesis, Deduction and Experiments:

Biological problem is a set of questions to be solved, about the natural world. These problems can be environmental, ecological, health related, etc. No matter what types of problems are being studied, scientists use the same problem-solving method to find answers that are logical and supported by evidence. Here we take an example of malaria (the greatest killer disease of man for centuries). You are familiar with the disease of malaria which spread through a female Anopheles mosquito. Previously the cause of malaria was unknown. It was thought that the malaria is caused by “bad air” (Latin word: 'mala' means bad, and 'aria' means air). This problem is solved when a Scientist identified the reason of malaria.

Observation:

The first step is to identify the reason of the problem followed by the formulation of a question about what has been observed. The solution of biological problem starts with observation. Your observation can be on anything from plant movement to animal behavior. An observation is a statement of knowledge gained through the senses (qualitative) or through the use of scientific equipment (quantitative).

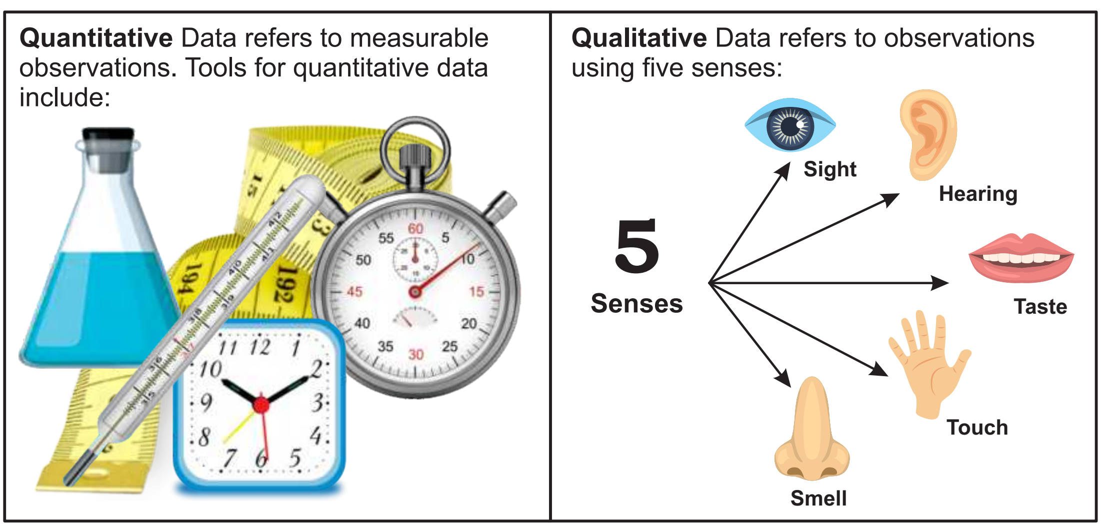
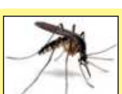


Figure 2.2 The qualitative and quantitative observation



About 280 million people suffer from malaria in over 100 countries, and more than 2 million die every year from the disease.

In 1880, a French physician, ***Laveran***, studied the blood sample of malaria patient under microscope and observed tiny creatures in it and named as ***Plasmodium***. So the observation was made that Plasmodium is present in the blood of malaria patients.

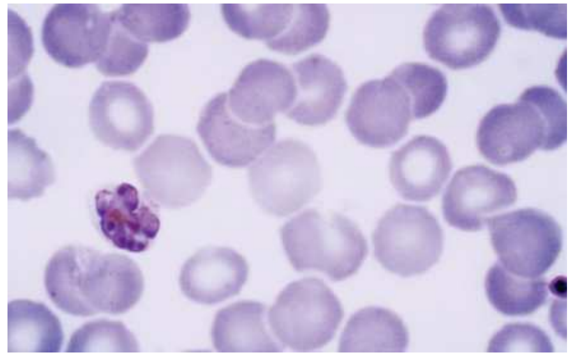


Figure 2.3 Plasmodium in blood sample

Hypothesis:

Hypothesis is a key component of the scientific process. It is defined as "the intelligent guess made by a scientist in the form of statement". It is important to note that a hypothesis must be testable. That means, you should be able to test your hypothesis through experimentation. Your hypothesis must either be supported or falsified by your experiment.

For Example: In malaria case, an intelligent guess is made after observation that **Plasmodium is the cause of malaria**. But it is only a guess which can be presented as a hypothesis.

Reasoning:

Biologists collect information about the problem and formulate the hypothesis by using a reasoning process i.e. 'inductive reasoning and deductive reasoning'.



Figure 2.4 A female Anopheles mosquito

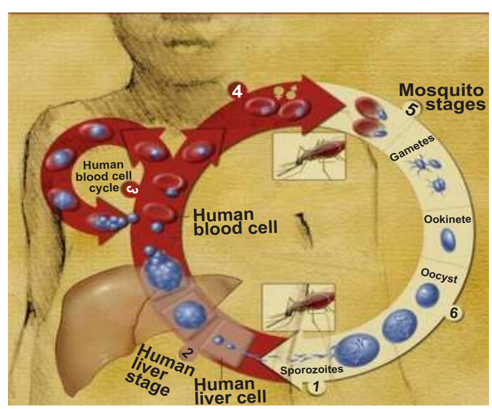


Figure 2.5 The Malarial Parasites (Plasmodium)

- **Inductive reasoning** moves from specific to general e.g. Shark is a fish. All fishes have scales therefore sharks also have scales.
- **Deductive reasoning** moves from general to specific. It is based on "if-then" statement. Deductive reasoning can be tested and verified by experiments. In malaria case, the following deduction is made:

"If *Plasmodium* is the cause of malaria, then all the malaria patient should have Plasmodium in their blood" as shown in figure 2.3.

Experiment:

Once a problem has been observed and a hypothesis is suggested, the next step in the scientific method is to design an experiment based on reasoning.

Experiment is a practical performance of a scientist to identify the real cause of a problem based on inductive and or deductive reasoning. A key assumption is that the experiment will be repeated many times by other scientists.

Scientist performs two types of test i.e. **control group** and **experimental group**. To find out the cause of malaria, blood samples of 100 malaria patients (experimental group) and the blood samples of 100 healthy persons (control group) were examined under microscope.



Figure 2.6 Hypothesis, an intelligent guess which leads the scientist to perform Experiment.

Result

The results are where you report what happened in the experiment. That includes detailing all observations and data made during your experiment. Result verifies the hypothesis. In the case of malaria, it was found that *all the malaria patients (experimental group) had Plasmodium in their blood whereas the blood samples of healthy persons (control group) were free from Plasmodium.*

Conclusion:

The final step of the scientific method is developing conclusion. This is where all the results from the experiment are analyzed and a determination is reached about the hypothesis. If your hypothesis was supported, its great. If not, repeat the experiment or think of other ways to improve your procedure.

Example: Conclusion is made that *"Plasmodium is the cause of malaria".*

2.1.2 Theory, Law and Principle:

Theory:

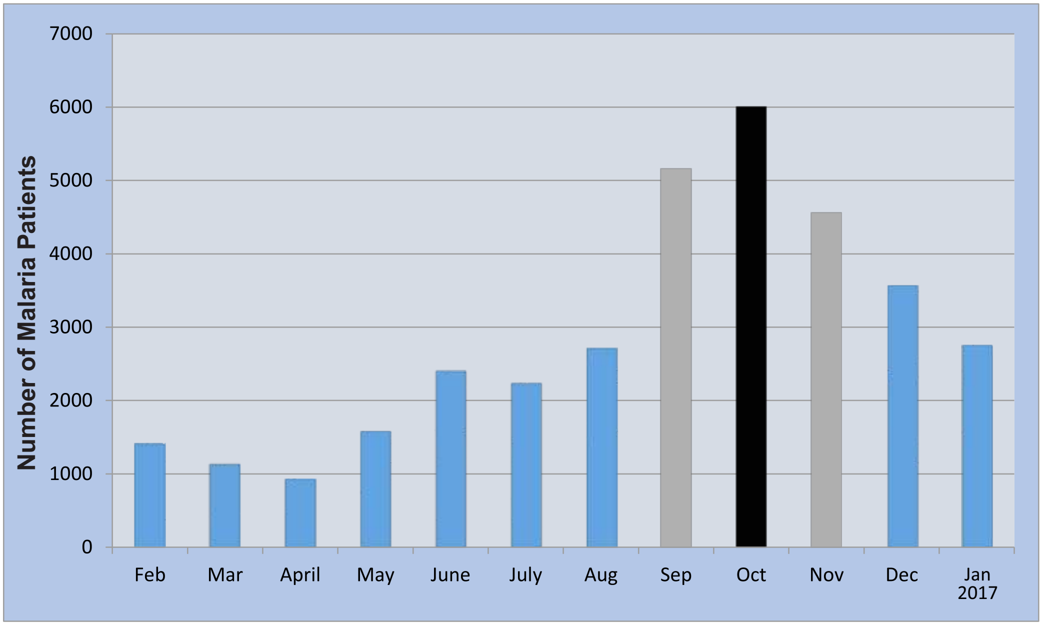
Scientists use the word "theory" in a very different way than non-scientists. When many people say "I have a theory", they really mean "I have a guess". Scientific theories, on the other hand, are well-tested and highly reliable scientific explanations of natural phenomena. They unify many repeated observations and data collected from lots of experiments. For example Theory of Evolution.

Law and principle:

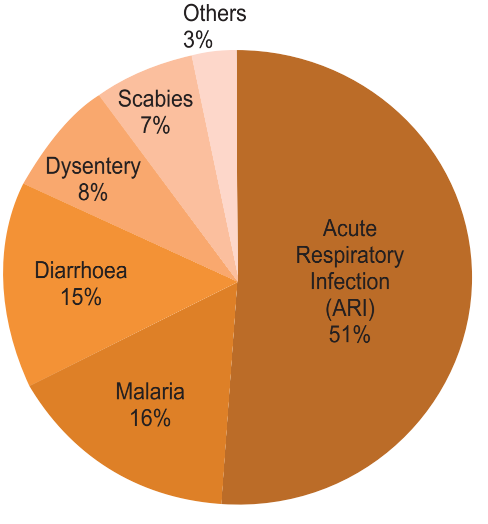
A scientific law is a uniform or constant fact of nature, it is virtually an irrefutable theory. Biology is short in laws due to puzzling nature of life.

2.1.3 Data organization and Data analysis:

For data organization you will prepare a table or graph of the data. Don't throw out data points you think are bad or that don't support your predictions. Some of the most incredible discoveries in science were made because the data looked wrong! Once you have recorded the data, you may need to perform a mathematical analysis to support or refuse your hypothesis.



A bar chart showing the trend of malaria cases reported in Sindh 2016-17



A Pie Chart showing Infectious diseases in Pakistan (2006)

In data analysis, the statistical methods (ratio and proportion) are applied. **Ratio** is a comparison of two values expressed as a quotient (1st/2nd). Example: A flower has 4 sepals and 12 petals. The ratio of sepals to petals is 4:12. This ratio can also be expressed as an equivalent fraction 1:3. A **Proportion** is an equation stating that two ratios are equal. Example: 4:12::1:3.

2.1.4 Mathematics as an integral part of the scientific process:

Imagine that you are a biologist studying the insect population. You go into the field and count the population sample in a specific region, then compare your sample with other regions to get population estimated. At every step of this process, you depend upon mathematics to measure, predict, and understand natural phenomena.

Mathematical biology is a field of research that examines mathematical representations of biological systems. One key role of mathematics in biology is the creation of **mathematical models**. There are equations or formulas that can predict or describe natural occurrences, such as organism behavior patterns, population changes over time, structure of protein, height of living organisms, population of an endangered species, bacterial growth and so on. Finally we can say that mathematics plays a critical role in better understanding the natural world.

Summary

- Science is the systematic study of nature and how it affects us and the environment.
- The biological method is the stepwise process in which a scientist finds out the reason of any biological problem about living things.
- An observation is a statement of knowledge gained through the senses (qualitative) or through the use of scientific equipment (quantitative).
- Your question should tell what it is that you are trying to discover or accomplish in your experiment.
- A hypothesis is an idea that is suggested as an explanation for a natural event, particular experience, or specific condition that can be tested through definable experimentation.
- The deductive reasoning involves the use of “if-then” logic. It moves from general to specific.
- Result includes detailing all observations and data made during your experiment.

- Conclusion is where all the results from the experiment are analyzed and a determination is reached about the hypothesis.
- Theories are the well-tested and highly reliable scientific explanations of natural phenomena.
- A scientific law is a uniform or constant fact of nature.
- Mathematical biology is a field of research that examines mathematical representations of biological systems.

Review Questions

1. Encircle the correct answer:

(i) Select the correct sequence of biological method.

(a) Law → Theory → Reasoning → Hypothesis

(b) Hypothesis → Theory → Law → Reasoning

(c) Hypothesis → Reasoning → Theory → Law

(d) Law → Hypothesis → Reasoning → Theory

(ii) Select the odd one

(a) Theory (b) Law

(c) Hypothesis (d) Ratio

(iii) Field of research that examines mathematical representations of biological system called.

(a) Ratio (b) Mathematical biology

(c) Proportion (d) Law

(iv) Biological method involves all of the following except.

(a) Data collection (b) Observation

(c) Experiment (d) Proportion

(v) Scientific reasoning moves from specific to general.

(a) Inductive (b) Deductive

(c) Observation (d) Both a and b

(vi) Quantitative observation is the use of

(a) Senses (b) Equipment

(c) Guess (d) Ratio

(vii) Equation stating that two ratios are equal

(a) Ratio (b) Proportion

(c) Guess (d) Senses

(viii) The comparison of two values is called

(a) Ratio (b) Proportion

(c) Graph (d) Table

(ix) What is a hypothesis?

(a) The same thing as an unproven theory.

(b) A tentative explanation that can be tested and is falsified.

(c) A verifiable observation.

(d) A fact based on quantitative data that is falsified.

(x) In data organization, which method is mostly useful?

(a) Table (b) Graph

(c) Ratio (d) Both a and b

2. Fill in the blanks:

(i) Problem solving approach of biology and other sciences called__________.

(ii) Solution of biological problem starts with___________.

(iii) The key component of the scientific process is ___________.

(iv) Scientific reasoning based on "if-then" statement called ____________.

(v) Final step of the scientific method is developing ____________.

(vi) The uniform or constant fact of nature, virtually an irrefutable theory is ___________.

(vii) Once you have the data, you may need to perform ____________ analysis.

(viii) The equation stating that two ratios are equal is called __________.

(ix) Ratio is comparison of _______ values.

(x) The cause of malaria is ___________.

3. Define the following terms:

(i) Ratio (ii) Biological method (iii) Graph

(iv) Hypothesis (v) Law (vi) Inductive reasoning

(vii) Conclusion (viii) Proportion (ix) Observation

(x) Mathematical models

4. Distinguish between the following in tabulated form:

(i) Theory and Law

(ii) Inductive reasoning and deductive reasoning

5. Write short answers of following questions:

(i) Theory is highly reliable scientific explanations, why?

(ii) Why biological sciences need mathematical models?

(iii) Draw a chart showing steps involved in biological methods.

(iv) Why table or graph is necessary for data organization?

(v) Why experiment is necessary for theory?

BIODIVERSITY

Chapter 3

Major Concept

In this Unit you will learn:

- Definition and Introduction of Biodiversity
- Aims and Principles of Classification
- History of Classification Systems
    - Two-Kingdom Classification System
    - Three-Kingdom Classification System
    - Four-Kingdom Classification System
    - Five-Kingdom Classification System
- The Five Kingdoms
- Binomial Nomenclature
- Conservation of Biodiversity



Nature has made the man with intelligence and he is always concerned with his aims to be achieved. He designs the things for this purpose into sequence. Similarly biologists mapped the whole diversity of organisms exist on earth, into simple groups. To understand about the characteristics of specific organisms individually, is simply called classification.

Classification is actually based on the similar and dissimilar characteristics what organisms shared with each other and by this biologists can easily study and identify the organisms.

3.1 DEFINITION AND INTRODUCTION OF BIODIVERSITY

Biodiversity is the combination of two words; **Bio (life), diversity (variation)** thus it is defined as; "The biodiversity or biological diversity is the degree of variation within or among the species exist on different regions of the earth". It is comprised of different organisms such as bacteria, protozoans, algae , fungi , animals and plants.

3.1.1 Importance of Biodiversity:

Biodiversity provides many beneficial products which includes fiber, oil, dyes, rubber, water, timber, paper and food. It also stabilizes the ecosystem by recycling the nutrients, reduces the amount of pollution by means of forest. Biodiversity also plays an important role in drug discovery and medicinal resources. Medicines from nature account for usage by 80% of the world's population. It also beautifies the nature with lots of tress and animals found in different regions which enhances the tourism.

Pictorial view of major biodiversity on earth:



Angiosperm plant



Gymnosperm Plant



Hornworts Liverworts Mosses

Figure: 3.1(a) variety of plants on earth.



Polar bear



Desert hopping mouse



Blue Bird



Cobra

Figure 3.1.(b) variety of different animals on earth

Can you identify other life on earth?

3.2 AIMS AND PRINCIPLES OF CLASSIFICATION

A system of classification is necessary because of the abundance of the variety of life on earth. There are currently around 1.5 million species that have been described and have been given scientific names. In future, more can be identified if they are found.

To study such a diverse pack of organisms exist on earth, biologists classified the organisms into groups and sub groups. This grouping of organisms is called **biological classification**.

3.2.1 Principles of Classification:

Some organisms share similar fundamental characteristics or functions. It is further explained by means of **Morphology** (external features of an organism) in which we study the organisms on the basis of their **Homologous** (similar in structure and have different functions) and **Analogous** (different in structure and have same functions). As shown in fig 3.2 a and b.

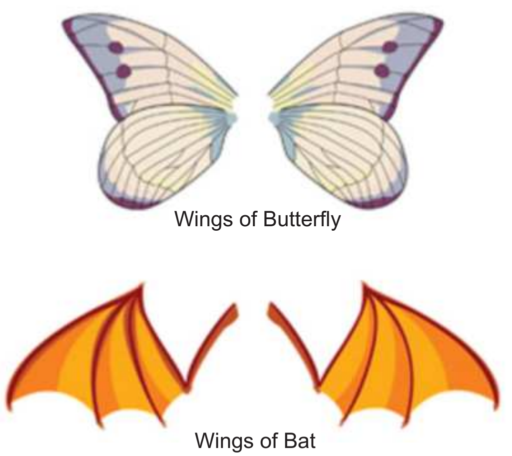


Figure 3.2 (a) Analogous structure

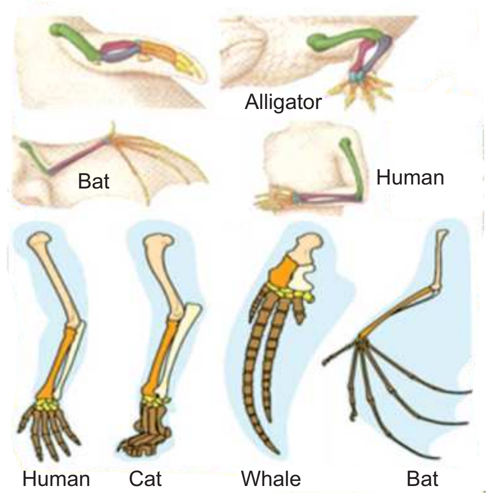


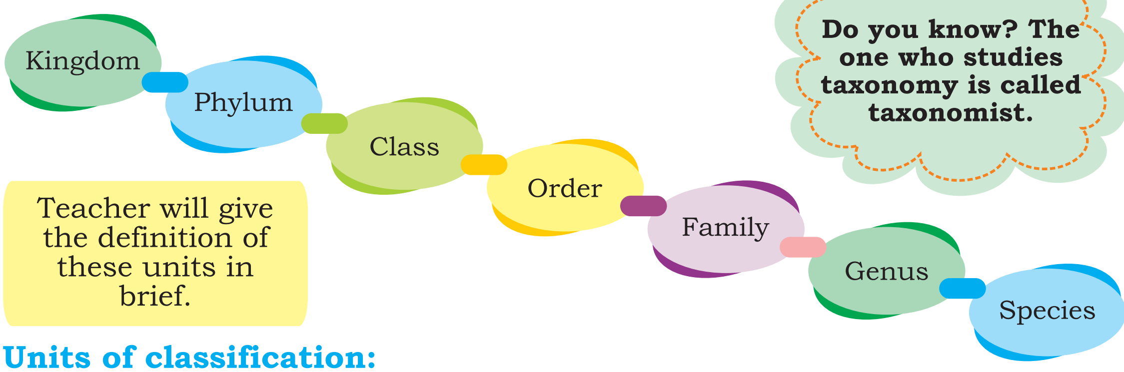
Figure 3.2 (b) Homologous structure

Have you seen the arm of a man and wing of a bird?
Which type of structure is this?

Sometimes it is impossible to classify organisms using morphological characters, therefore scientists use other characteristics to classify organisms which include; Cytology and genetics in which organisms are classified on the basis of cellular study, genetic constitution and their development pattern. Biochemistry is also employed in which the chemical substances of the organisms are compared.

Taxonomic Hierarchy

The groups into which organisms are classified are known as taxonomic categories or taxa (singular taxon). The taxa are arranged in ascending order and form a ladder, called taxonomic hierarchy. All organisms are classified into five kingdoms, so the kingdom is the highest taxon of classification. On the basis of similarities, each kingdom is further divided into smaller taxa in the following ways:



Do you know? The one who studies taxonomy is called taxonomist.

Teacher will give the definition of these units in brief.

Units of classification:

The smallest and basic unit of classification is species. Taxonomic studies consider a group of individual organisms with the fundamental similarities as a species. Thus all the members of the particular species share the similar characteristics and can naturally interbreed to produce a fertile offspring. Closely related species are grouped together into genera (singular-genus). Similar genera are grouped together into families, families into orders, orders into classes, classes into phyla or division and phyla or division into kingdoms.

Simple Classification of two Organisms

Taxa	Human	Pea
Kingdom	Animalia	Plantae
Phylum	Chordate	Magnoliophyta
Class	Mammalia	Magnoliopside
Order	Primates	Fabales
Family	Moninidae	Fabaceae
Genus	Homo	Pisum
Species	Sapiens	Sativum
Scientific name	Homo sapiens	Pisum sativum

3.2.2 Aims of Classification:

Biologists classified the organisms in order to make them study easily, so the science of classification is called **Taxonomy**.

(Tazm=group, Nomy=naming)

The main aims of this branch are;

- To determine similarities and dissimilarities among organisms so that they can be studied easily.
- To find the evolutionary relationship among organisms.

Use internet to search out THREE different species belongs to same Genus.

3.3 HISTORY OF CLASSIFICATION

The system that we still use today for giving scientific names to plants and animals has many founders, from the Greek philosopher **Aristotle** to the Swedish physician and botanist **Carolus Linnaeus**. Taxonomy's first father was the philosopher Aristotle (384-322 BC), sometimes called the "father of science." It was Aristotle who first introduced the two key concepts of taxonomy as we practice it today: classification of organisms by type and binomial definition.

Aristotle was the first to attempt to classify all the kinds of animals in his book on Animals (Historia Animalium in Latin). He grouped the types of creatures according to their similarities: animals with blood and animals without blood, animals that live on water and animals that live on land.



Aristotle



Abu usman Umer Aljahiz

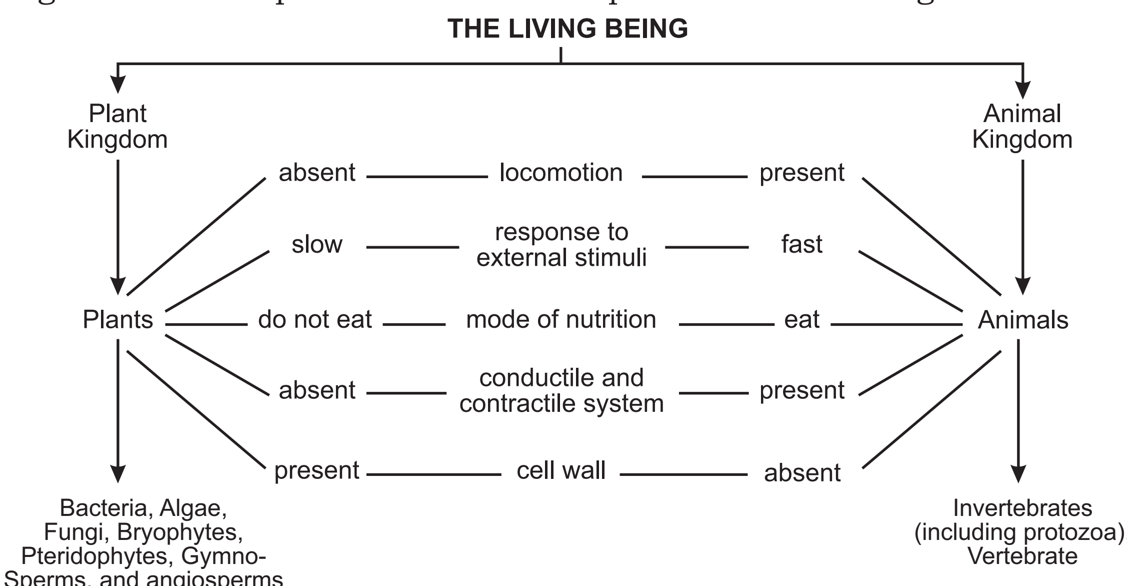
Abu Usman Umer Aljahiz was the first eminent Arab zoologist of the Muslim world.

He used to slaughter animals for studying the internal organs of their bodies. He also opened the abdomen of pregnant animals to find out the number of embryos and the location of each one of them in the body. His Encyclopedic work in seven big volumes **Kitab al-Haywan (Book of Animals)** is the most famous work on zoology, in which he has described in detail, the kinds of animals, their behavioral characteristics and their diseases and treatment.

Carolus Linnaeus is considered as the father of Taxonomy.

3.3.1 Two Kingdom classification:

Previously the organisms were classified into two groups; all the organisms possess cell wall were placed in plant kingdom and all the organisms do not possess cell wall were placed in animal kingdom.



Two kingdom classification

3.3.2 Three Kingdom classification

Ernst Hackle in 1866, introduced a new Kingdom named as Protista to accommodate the organisms exhibiting characters either common to both plants and animals, or unique to their own such as Euglena, Bacteria were also placed under this kingdom.

In 1937, ***Édouard Chatton*** clearified the concept of procariotique and Eucariotique to describe the cellular characteristics of organisms.

In 1930s, electron microscopy revealed, two distinct patterns among single celled organisms:

Kingdom Protista

- Lower protists
  prokaryotic unicellular
  Bacteria and Cyanobacteria
- Higher protists
  eukaryotic unicellular
  or multicellular organisms
  such as fungi algae
  except blue green algae

3.3.3 Four kingdom classification:

After the clear concept for kingdom Protista, Copeland (1959) came forward with a four kingdom system to classify the living beings. He designed a new kingdom named as Monera to place all the lower protists which include prokaryotic unicellular organisms and remaining single celled eukaryotic organisms were included in Protista.

THE LIVING BEING

Kingdom Monera	Kingdom Protista	Kingdom Metaphyta	Kingdom Metazoa
↓	↓	↓	↓
Lower protists (Prokaryotic protists)	Higher protists (Eukaryotic protists)	Plants (Eukaryotic)	Animals (Eukaryotic)
↓	↓	↓	↓
Becteria and Blue Green algae	Algae and Fungi	Bryophytes, pteridophyte, Gymnosperms and Angiosperms	Invertabrates and Vertebrates

Four Kingdom classification

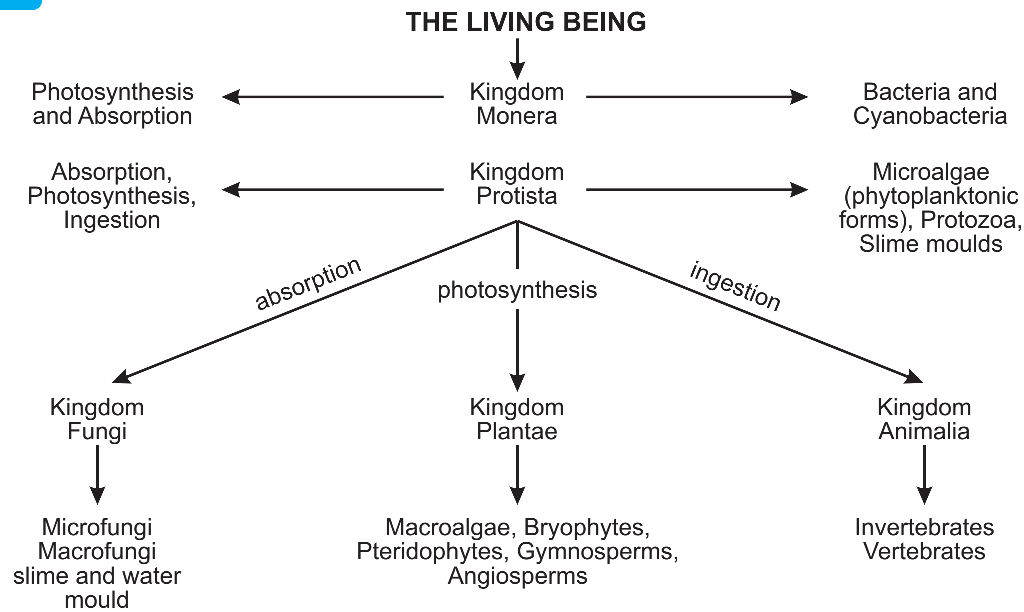
3.3.4 Five Kingdom Classification:

Robert Whittaker in 1969 classified the organisms into Five kingdoms which clearly categorized fungi into a separate kingdom.This system of classification was based on;

- Cellular structure and body organization; unicellular Prokaryote, Unicellular and multicellular eukaryotes.
- Mode of nutrition; autotrophs (plants), Ingestive heterotrophs (animals) and absorptive heterotrophs (fungi).

Draw a linkage chart to show the establishment of Five Kingdom System that includes Two to Five Kingdom classification.

3.4 THE FIVE KINGDOMS



Five Kingdom classification

(i) Kingdom Monera:

It includes all the prokaryotes i-e Bacteria and cyanobacteria.

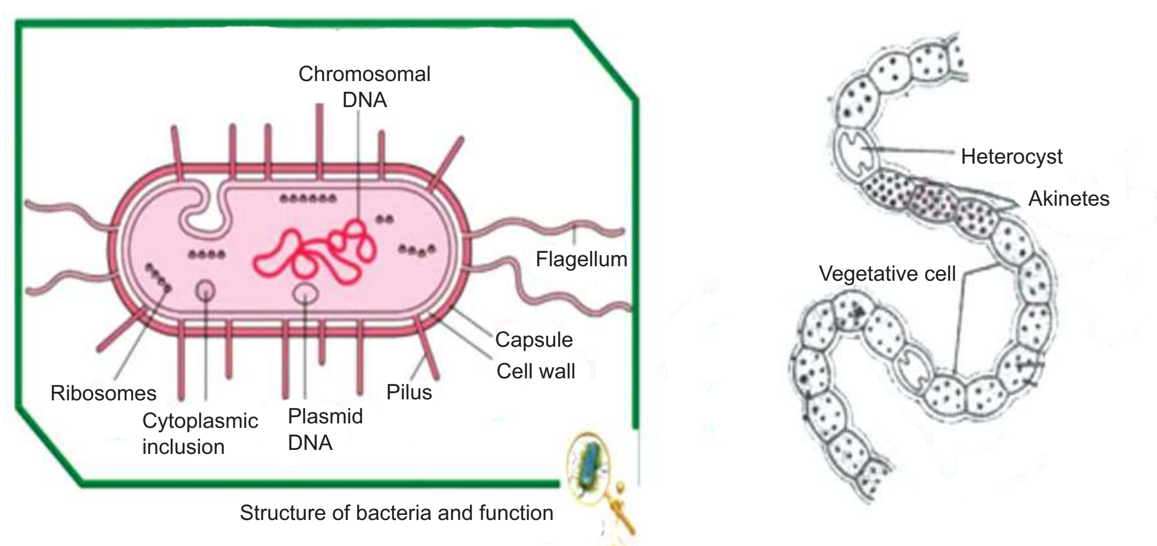


Figure 3.3 Bacteria and cyanobacteria

(ii) Kingdom Protista:

It is the place for all the eukaryotic unicellular organisms, except yeast which some of them have the features of both plant and animal like. Most protists are aquatic. It includes protozoa and unicellular algae.


Paramecium

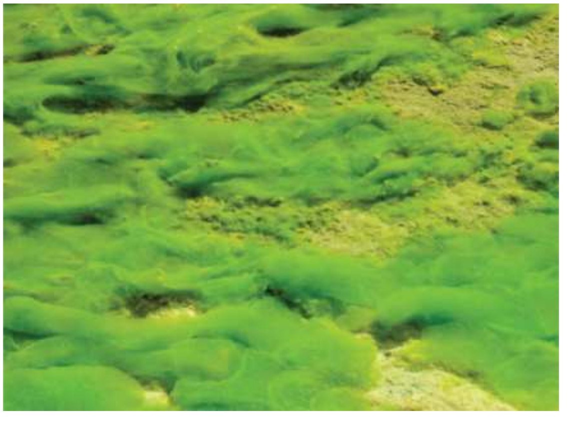

Algae

Figure 3.4 protozoa and algae

(iii) Kingdom Fungi:

It includes all the multicellular eukaryotic fungi. They are Achlorophyllous, absorptive heterotrophs. They have cell wall made up of mainly chitin. They have a body called Mycelium which is made up of a thread like structure called hyphae.

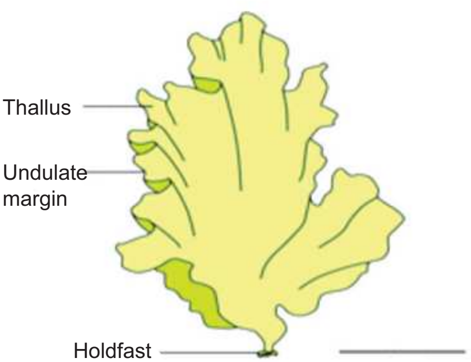

Mushroom


Mucor

Figure 3.5 Examples of fungi

(iv) Kingdom plantae:

It includes all the multicellular, eukaryotic, photosynthetic organisms. They have cell wall mainly made up of cellulose. It includes multicellular Algae, bryophytes, pteridophytes, gymnosperm and angiosperms.



Ulva lactuca



Bryophytes

Figure 3.6 Plants type

(v) Kingdom Animalia:

All animals are multicellular, eukaryotic which are ingestive heterotrophs without cell wall. It includes all vertebrates and invertebrates except protozoa.



Star fish



Kangaroo

Figure 3.7 Animals type

Table: Comparative characteristics of Five kingdom life.

Five Kingdoms					
Characters	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	(Polysaccharide + amino acid) or cellulose	Present in some	Present (without cellulose)	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular without bonded organelles	Cellular	Multicellular/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
mode of nutrition	Autotrophic (chemosynthetic photosynthetic) and Hetero-trophic (sapro-phyte/parasite)	Autotrophic (Photosyn thetic) and Hetero-trophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosyn thetic)	Heterotrophic (Holozoic/ saprophytic etc.)

Structure of Virus:

Virus is non cellular obligate endoparasite (lives inside host cell). It does not have cellular organization but do have nuclear material either DNA or RNA. It has protein coat called capsid that encloses the nucleic acid. It reproduces only inside the host cell. Due to its non-cellular nature it cannot be placed in any of the five kingdoms. It causes number of diseases in plant like tobacco Mosaic Disease etc and animals like, cold, flue, dengue, polio, hepatitis, AIDS etc.

Prions and viroids are also non-cellular particles so cannot be placed in five kingdom classification system

3.5 BINOMIAL NOMENCLATURE

Carolus Linnaeus Swedish naturalist and explorer who was the first to frame principles for defining natural genera and species of organisms and to create a uniform system for naming them. The advantages of scientific over common names are that they are accepted by speakers of all languages, that each name applies only to one species, and that each species has only one name. As common names cause many problems to identify the organisms as different regions have different languages for the same thing for example; common name of onion in Urdu is 'Piyaz' but in other regions it is also known as 'ganda' or 'basal' etc but in scientific language it is known as **Allium cepa**.

This avoids the confusion that often arises from the use of a common name to designate different things in different places or from the existence of several common names for a single species.

Table: Biological name of some common plants and animals.

	COMMONE NAME	BIOLOGICAL NAME
	PLANTS	
1.	Onion plant	*Allium cepa*
2.	Mango plant	*Mangifera indica L.*
3.	Neem plant	*Azadirachta indica*
	ANIMALS	
1.	Frog	*Rana tigrina*
2.	Cat	*Felis catus*
3.	Housefly	*Musca domestica*

Through a system of nomenclature in which each species of animal, plant or others receives a name of two terms of which the first identifies the genus to which it belongs and the second the species itself or its specific names.

Principles for binomial nomenclature:

Some of the rules which are universally adopted for writing scientific name of a species are:

- Scientific name of any organisms should be italicized when printed, such as *Homo sapiens* and when handwritten these are underlined.
- The first word of the name is generic always started with capital letter, while second term is species which is never capitalized.
- When the scientific name is written first time, it is written full but when it is repeated several times, it is abbreviated. For example; The scientific name of the red rose is *Rosa indica*, it is abbreviated as *R.indica*.
- Sometimes the author name appears after species name which means the species was described by Him. For example; (mango plant) *Mangifera indica* L. It means *Mangifera indica* was first described by ***Linnaeus***.

Use internet to search a scientific name of potato, matar, china rose and Dog.

3.6 CONSERVATION OF BIODIVERSITY

Pakistan is one of few countries in the world to have every kind of geological structure. The geography of Pakistan is a blend of landscapes.

You'll find plains, deserts, forests, hills, and plateaus. There are coastal areas along the Arabian Sea and mountains of the Karakoram Range in the north part of Pakistan.




Figure 3.8 Beautiful views of Pakistan

This diversity contains diversified habitats and landscapes that support a rich biodiversity of both fauna and flora (animals and plants respectively). Arid and semi-arid regions covering almost 80% of the total land area of the country possess significant portion of country's biodiversity. During the last two-three decades, a number of animal and plant species have become threatened or endangered mainly due to over-exploitation and loss of natural habitat. Factors like deforestation, overgrazing, soil erosion, salinity and water logging are posing major threats to the remaining biodiversity of the country. The continuing loss of forest habitat, with its associated fauna and flora, will have serious implications for the nation's other natural and agricultural ecosystems. To overcome all these problems biodiversity should be paid attention in order to save the organisms from being endangered. **"Conservation simply is the way of caring, saving the species, inhabit on earth from dangers"**.

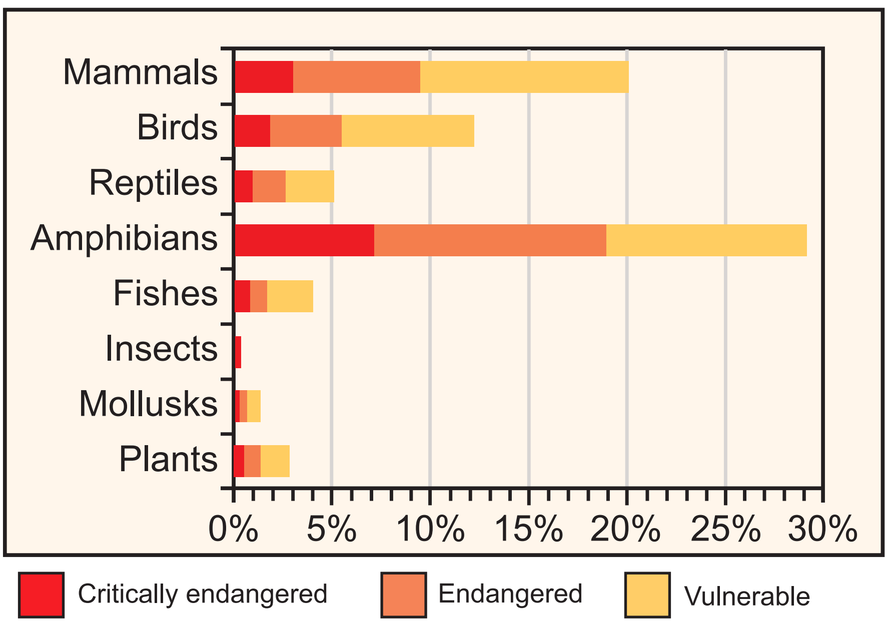
3.6.1 Reasons to conserve Biodiversity

Biologists warned that global ecosystem would be collapsed if biodiversity continues to be reduced at the same rate. Therefore, it is mandatory to conserve life on earth in order to make nature stable.

Some of the key points are highlighted below:

- Human should **conserve biodiversity** because of its benefit for example services and biological resources which are essential to live our life on earth.
- Biodiversity boosts ecosystem productivity where each species can easily survive in their habitat, if the one will not conserve biodiversity, so food chain and ecosystem will be imbalanced.
- With more plants, trees and animals, the soil improved and became stronger - less prone to erosion, drought and flooding.

Graph: Reporting the data to show the biodiversity at risk.



3.6.2 Problems associated to conserve biodiversity in Pakistan:

The article from 2009“Biodiversity in Pakistan Key issues”, identified some of the primary challenges to implement Biodiversity Action Plan (BAP) are:

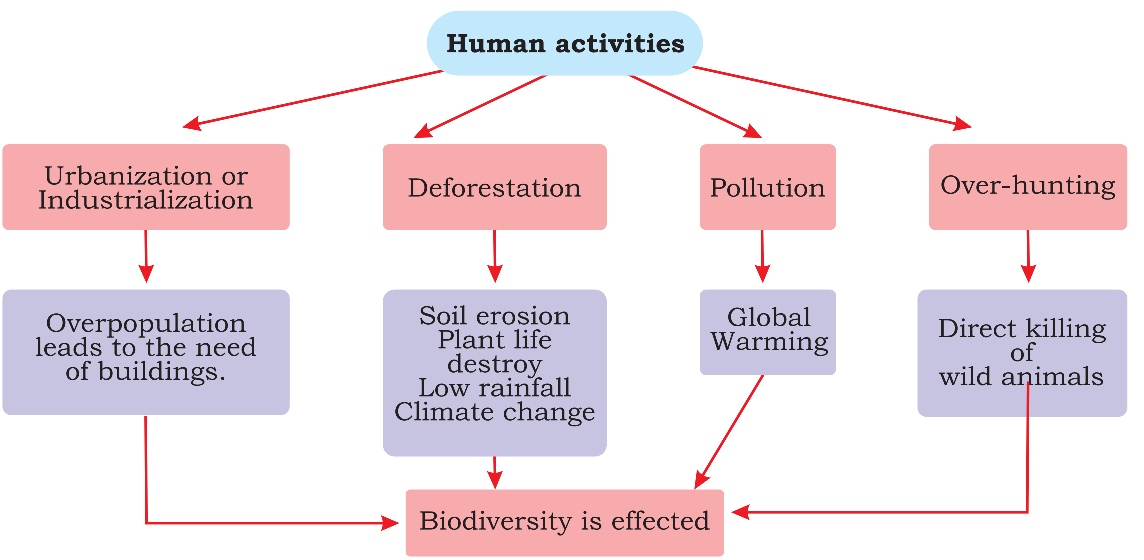
- Lack of awareness of environmental issues on the part of decision-makers and civil society.
- Weak governance (slow decision-making processes, inability to conceptualize policy, and lack of distinction between public and private interests).

- Weak capacity of government departments (lack of individual capacity and incentives for performance).
- Lack of funding.

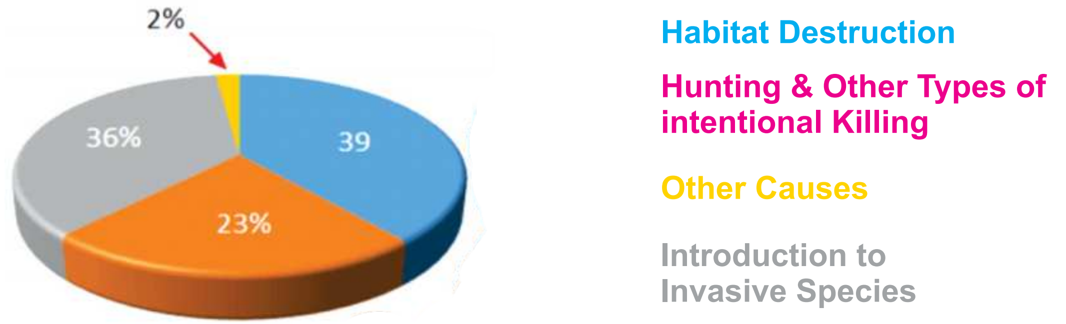
3.6.3 Problems associated to conserve biodiversity due to human intervention:

The International Union for Conservation of Nature (IUCN) reported that 75 percent of genetic diversity of agricultural crops has been lost, 75 percent of the world's fisheries are over exploited, and one-third of coral reefs are threatened with extinction. Man is the factor, which is directly involved in the destruction of biodiversity. The table below show some of the human intervention in the loss of biodiversity.

Table: Impact of human activities on Biodiversity.



Causes of Animal Extinction (Pie Chart)



Climate changes are not the only pressure on our environments. Habitat loss and degradation, pollution, overexploitation, and invasive species also play significant roles in biodiversity decline. These pressures are because of human invading activity.

3.6.4 Deforestation-causes and its effect on Biodiversity

Forests cover 31% of the land area on our planet. They produce vital oxygen and provide homes for people and wildlife. Many of the world's most threatened and endangered animals live in forests, and billions of people rely on its benefits. Forests offer food, fresh air, clothing, medicine and shelter. Forests play a critical role in reducing climate change because they act as a carbon sink soaking up carbon dioxide that would otherwise be free in the atmosphere and contribute to ongoing changes in climate patterns. But man is destroying this natural beauty by cutting them down for his sake and comfort. **"The cutting down of trees for the conversion of forest into non forest land is known as Deforestation"**.



Figure 3.9 Deforestation

Causes of Deforestation:

Deforestation is done deliberately due to the Mining, paper making, urbanization, timber, for making roads and Agriculture Expansion & Livestock breeding.

Effects of Deforestation:

Deforestation result with the great loss in Biodiversity such as; increase in the concentration of green house gases (carbon dioxide,

Methane, water vapopur, Nitrous oxide etc.) which leads to Global warming, temperature will be high that causes glaciers melting which is the reason of raising sea level and causes flood. It is also the reason of habitat loss of wild life. Soil erosion, low rainfall due to no transpiration are also the result of Deforestation.

3.6.5 Endangered and extinct species

Due to human activities such as entertainment or food, animals are becoming endangered (at risk of extinction in future) or some have gone extinct (surety of not finding the last individual of that species in ecosystem). Some of the endangered species are mentioned below:



Long Billed Vulture



Green Sea Turtle



Snow leopard



Marco polo sheep



European Otter



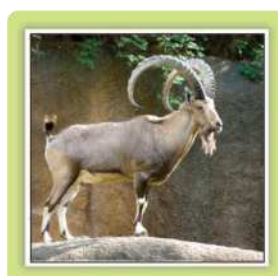
Baluchistan Forest Dormouse



Indus river dolphin



Asian black bear



Sindh Ibex (Markhor)

Figure 3.10 Endangered species of Pakistan

Summary

- Biodiversity or biological diversity is the degree of variation with or among species exist on different regions of the earth.
- Biodiversity provides many beneficial products including fibre, oil, dyes, ruber, water, timber, paper and food.
- Classification of organisms takes place on the basis of mological character or cytological character or genetical character.
- Morphological classification occur on homologous (Similar in structure) or an analogous characters (different in structure but similar in function).
- The groups of classified organism called taxon(Pl: taxa).
- The smallest and basic unit of classification is species. It is a group of organism which are similar in structure, can interbreed to provide fertile and visible off spring.
- The arrangement of taxa in ascending order to form a ladder called Taxanomic hierarchy.
- The science of classification is called Taxanomy.
- The father of Taxanomy is *Carolus Linnaeus.*
- *Carolus Linnaeus* gave the concept of binomial Nomenclature.
- In the beginning living organism were classified into two kingdom plant and animal kingdom.
- *Ernst Hackle* in 1866 introduced thee kingdom system.
- *Copeland* in 1959 classified living organism in four kingdoms.
- *Robert Whittaker* classified organism in 5 kingdoms, Monera, Protista, fungi, plantae and animalia.
- Lack of awareness of environmental issues, weak governance, etc are the main problems associate to conserve biodiversity.

Review Questions

1. Encircle the correct answer:

(i) Which of the following is the correct way of writing a scientific name of an organism?

(a) *Houbara bustard* (b) E.coli

(c) Alium Cepa (d) canis lupis

(ii) Select the mismatched

(a) Plantae → Pteridophyta (b) Fungi → Mucor

(c) Protista → Paramecium (d) Animalia → Amoeba

(iii) Identify the correct sequence of classifying an organism.

(a) Species → Genus → Kingdom → Phylum → Class → Order → Family

(b) Kingdom → Phylum → Class → Order → Family → Genus → Species

(c) Kingdom → Phylum → Class → Family → Order → Genus → Species

(d) Species → Genus → Class → Phylum → Order → Kingdom → Family

(iv) All are involve in classification except

(a) Analogous (b) Homologous (c) Cytology (d) Genetics

(v) In the taxonomic hierarchy choose the term which encompasses all other in the list

(I) Genus (II) Species (III) Order (IV) Class

(a) I and II (b) II (c) II and III (d) IV

(vi) In four kingdom classification, kingdom Metaphyta includes all of the following except.

(a) Algae (b) Angiosperm

(c) Gymnosperm (d) Bryophyta

(vii) In five kingdom system virus placed in

(a) Monera (b) Protista

(c) Plantae (d) None of these

(viii) Biological name of cat

(a) Felis catus (b) Azadirachta indica

(c) Alium Cepa (d) Canis lupis

(ix) Members of which kingdom have cell wall and are all heterotrophic

(a) Monera (b) Protista (c) Plantae (d) Fungi

(x) Biodiversity is effected with

(I) Pollution (II) Deforestation (III) Over hunting

(a) I only (b) II only (c) I and II (d) I, II and III

2. Fill in the blanks:

(i) Degree of variation within or among the species exists on different regions of the earth called ______________.

(ii) _________ Species are given scientific names.

(iii) __________ Structures have different functions (physiology) but having similar internal architecture.

(iv) Science of classification is called ________.

(v) Most protists are _________.

(vi) ___________ are achlorophyllous and absorptive living organism.

(vii) ___________ is non-cellular obligate parasite.

(viii) Scientific name of any organism should be __________ when printed.

(ix) Cutting down of trees called _____________.

(x) Animals which are at the risk of extinction in future called ____________.

3. Define the following terms:

(i) Analogous (ii) Classification (iii) Species

(iv) Family (v) Metazoa (vi) Mycelium

(vii) Hyphae (viii) Genus (ix) Endangered species

(x) Kingdom

4. Distinguish between the following in tabulated form:

(i) Plant kingdom and Animal kingdom

(ii) Monera and protista (iii) Fungi and Plantae

5. Write short answers of following questions:

(i) Why scientific naming is necessary?

(ii) How living organisms are classified into two kingdom classification?

(iii) Why virus is not placed in any kingdom?

(iv) Draw chart showing three kingdom classification.

(v) Why amoeba is not placed in animal kingdom?

(vi) Why cyanobacteria are placed in monera?

6. Write detailed answers of the following questions:

(i) Describe in detail five kingdom classification.

(ii) What is taxonomic hierarchy? Explain aims of classification.

(iii) Describe effect of deforestation on biodiversity.

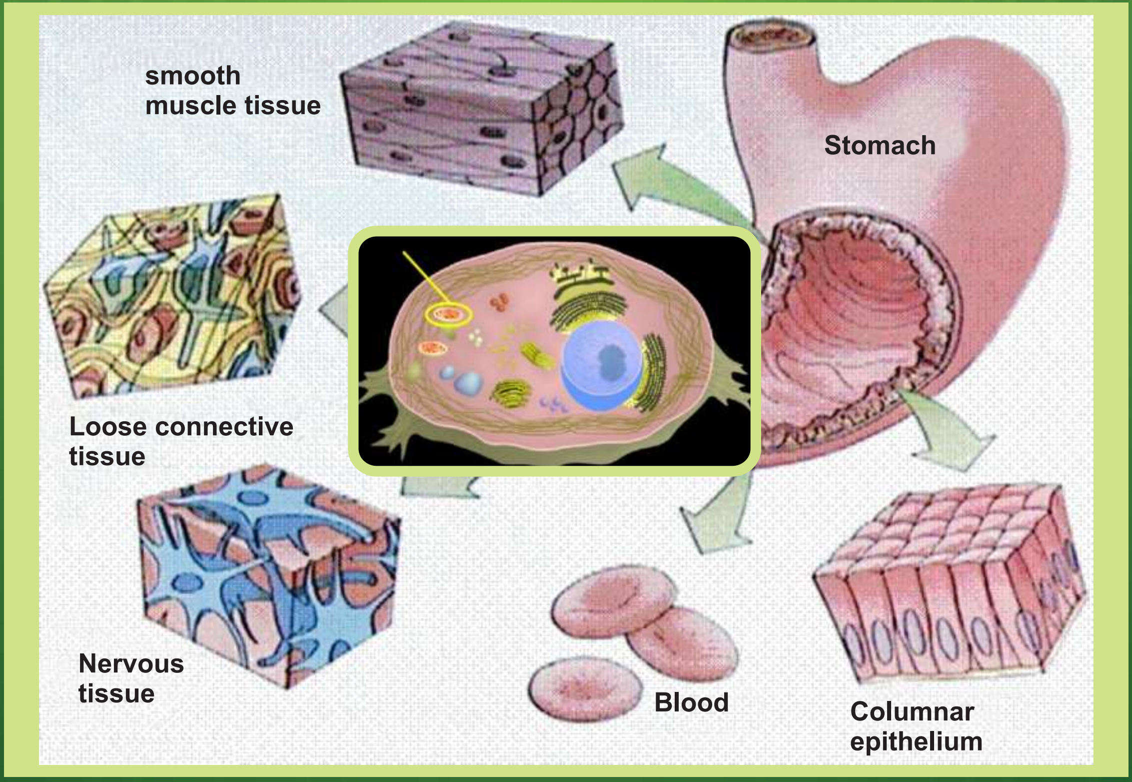
CELLS AND TISSUES

Chapter 4

Major Concept

In this Unit you will learn:

- Microscope and Emergence of Cell Theory
  - Light microscope and electron microscope
- Cellular Structures and Functions
  - Difference in prokaryotic and eukaryotic cells
  - Relationships between cells function and structure
- Cell size and shape as they relate to surface area to volume ratio
- Active and Passive Transport of Matter
  - Diffusion
  - Facilitated diffusion
  - Osmosis
  - Filtration
  - Active transport
  - Endocytosis
  - Exocytosis
- Tissues
  - Animal tissues
  - Plant tissues



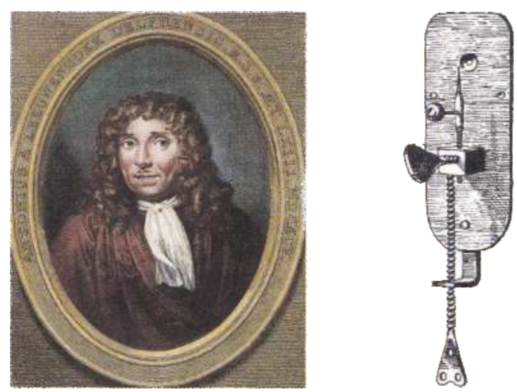
You could find cells just as intricately patterned and beautifully formed in any plant you looked at-from the rose in your backyard, to the grass growing up through the sidewalk, to the carrots you ate for a snack. Let's not limit it to plants, either: exquisite layers of cells can be found in your skin, in an insect's wing, and in just about any other living tissue you choose to look at. We, and the world around us, are made of cells. We just need some microscopy to appreciate it.

4.1 MICROSCOPE AND EMERGENCE OF CELL THEORY

Zacharias Janssen is generally believed to be the first investigator to invent the compound microscope in the 1590. It was simply a tube with lenses at each end and its magnification ranged from 3X to 9X.



Zacharias Janssen (1580-1638)



Van Leeuwenhoek's microscope

Robert Hooke had improved his version of the compound microscope to observe organisms.

Microscopes are instruments designed to produce magnified visual or photographic images of objects too small to be seen with the naked eye. There are two parameters especially important in microscopy; magnification and resolution.

Magnification: The enlargement of an image is called magnification. By combining a number of lenses in the correct manner, a microscope can be produced that will yield very high magnification values.

Resolution: The resolution of a microscope is defined as the smallest distance between two points on a specimen that can still be distinguished as two separate objects. It helps to measure clarity of object.

Both magnification and resolution are very important if you want a clear picture of something less than 0.1. For example, if a microscope has high magnification but low resolution, all you'll get is a bigger version of a blurry image.

4.1.1 Light microscope and electron microscope:

There are two microscopes are used in microscopy i.e. light microscope (LM) and electron microscope (EM).

(a) Light microscope:

In a light microscope, visible light passes through the specimen (the biological sample you are looking at). A photograph of an image taken through a microscope is called micrograph.

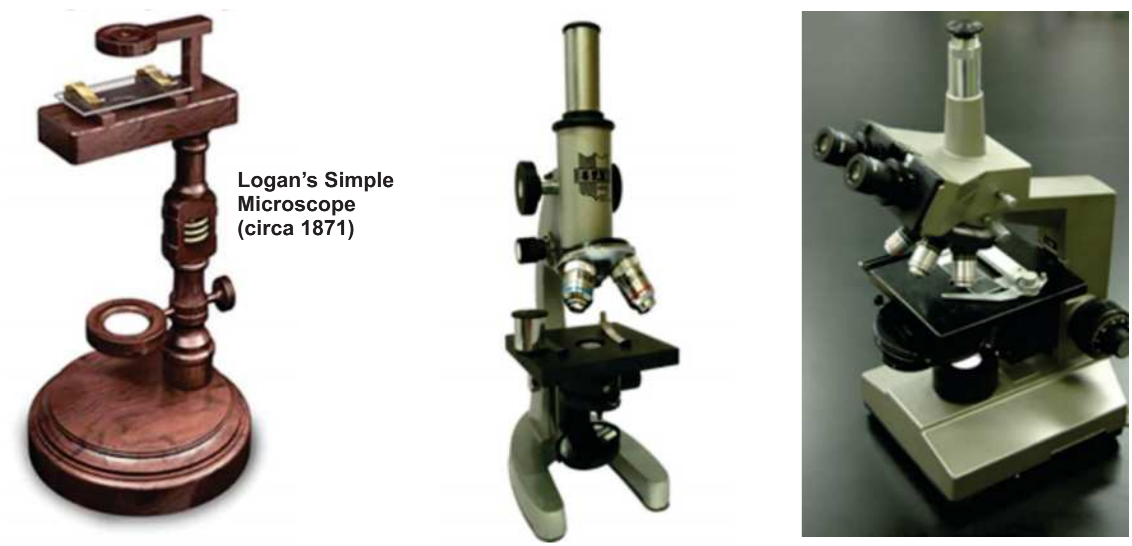


Figure 4.1 Light microscopes from simple to complex

The magnification of a light microscope is formed by using a mixture of the powers of the eye piece and the objective lens.

In order to ascertain the total magnification when viewing an image with a compound light micrscope, take the power of the objective lenses, which is at 4x, 10x, 40x and multiply it by the power of the eye piece which is typically 10x. Therefore, a 10x eyepiece used with a 10x objective lens will produce a magnification of 100x. This means that the object can be magnified, 40x, 100x or 400x.

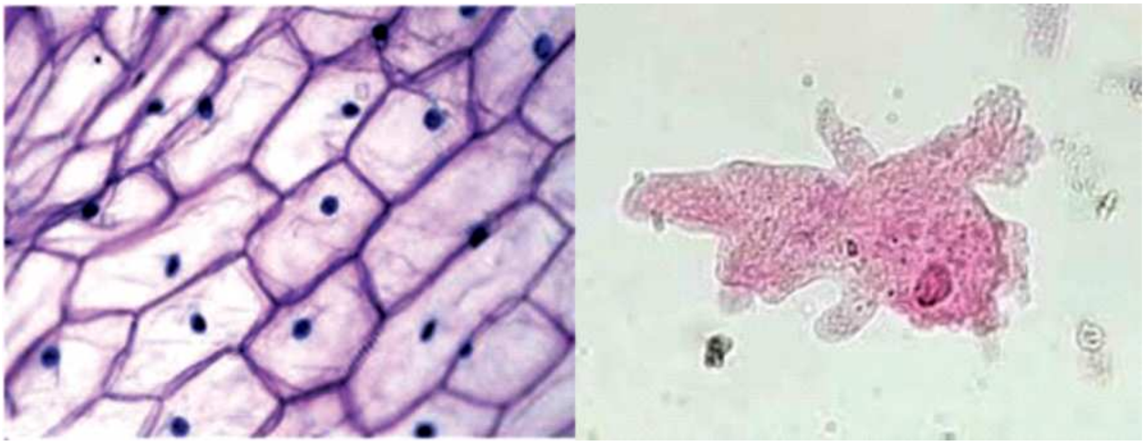


Figure 4.2 Light microscopic micrograph of onion cells and Amoebae

(b) Electron microscope:

Electron microscopes differ from light microscopes, that they produce an image of a specimen by using a beam of electrons rather than a beam of light. Electrons have a much shorter wavelength than visible light, and this allows electron microscopes to produce higher-resolution images than standard light microscopes. Electron microscopes can be used to examine not just whole cells, but also the subcellular structures and compartments within them. A live cell cannot be imaged by electron microscope.

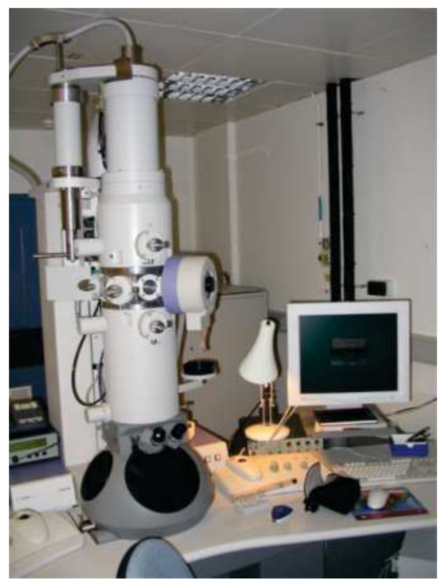


Figure 4.3 Electronic microscope (TEM)

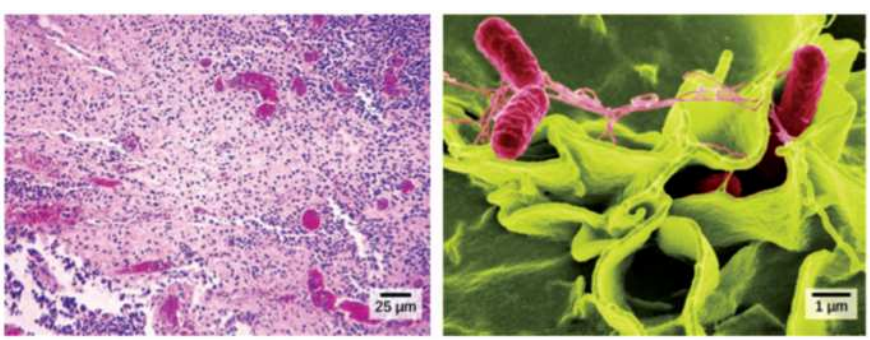


Figure 4.4 Salmonella bacteria under light micrograph (left) and through electron microscope (right).

Electron microscope has a resolution as small as 0.2 nanometer (nm) and magnification upto 250,000 times. There are two major types of electron microscopes.

1. Scanning electron microscopy (SEM)
2. Transmission electron microscopy (TEM)

In scanning electron microscopy, a beam of electrons moves back and forth across the surface of a cell or tissue, creating a detailed image of the 3D surface.

In transmission electron microscopy, in contrast, the sample is cut into extremely thin slices before imaging, and the electron beam passes through the slice rather than skimming over its surface. TEM is often used to obtain detailed images of the internal structures of cells.



Figure 4.5 SEM (left) and micrograph of Amphipod (right)

4.2 HISTORY OF THE DEVELOPMENT OF CELL THEORY

Ancient Greeks were the first to make comprehensive attempts to organize the data of the natural world. Aristotle presented an organized observation to support the idea that all animals and plants are somehow related. Later this idea gave rise to questions like 'is there a fundamental unit of structure shared by all organisms?" But before microscope was first used in 17th century, no one knew that living organisms do share a fundamental unit i.e. cell.

1665	Cell was first observed by ***Robert Hooke***, an English scientist, discovered a honeycomb-like structure in a cork slice using a primitive compound microscope. He only saw cell walls as this was dead tissue. He coined the term "cell" for these individual compartments he saw.
1670	First living cells were seen by ***Anton van Leeuwenhoek***, a Dutch biologist, from pond water with a microscope.
1683	**Miniature animals:** ***Anton van Leeuwenhoek*** made several more discoveries on a microscopic level, eventually publishing a letter to the Royal Society in which he included detailed drawings of what he saw. Among these was the first protozoa and bacteria discovered.
1833	The center of the cell was seen by ***Robert Brown***, an English botanist, discovered the nucleus in plant cells.
1839	**Cell theory:** ***Theodor Schwann***, a German botanist reached the conclusion that not only plants, but animal tissue as well is composed of cells.
1839	This ended debates that plants and animals were fundamentally different in structure. He also pulled together and organized previous statement on cells into one theory, which states: 1- Cells are organisms and all organisms consist of one or more cells. 2 - The cell is the basic structure unit for all organisms.
1840	Where does life come from ***Albrecht von Roelliker*** discovered that sperm and eggs are also cells.
1845	***Carl Heinrich Braun*** reworked the cell theory, calling cells the basic unit of life.
1855	3rd part to the cell theory added by ***Rudolf Virchow***, a German physiologist/physician/pathologist. Added that cell is not Denovo structure. This translates mean that all cells develop only from existing cells.
1862	***Louis Pasteur*** was a French biologist; microbiologist and chemist provided the experimental proof of this idea.

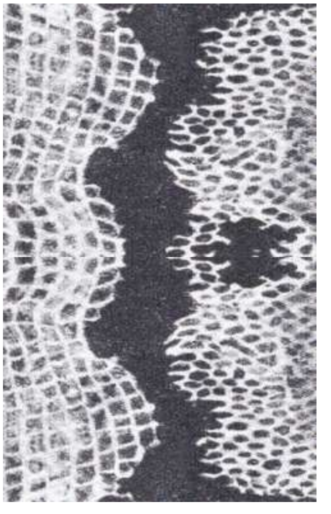



Figure 4.6 ***Robert Hooke*, an English scientist, discovered a honeycomb-like structure in a cork slice using a primitive compound microscope.**

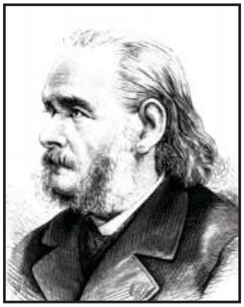
4.2.1 Cell theory:

One of the most important concepts in biology is that a cell is a basic structural and functional unit of living organism. This is known as a cell theory and was proposed jointly by two scientists in 1839. A Belgian Botanist called ***Schleiden*** and the German zoologist called ***Schwan***.

In 1855 ***Rudolf Virchow***, a German physicians proposed an important extension of cell theory-that all living cells arise from pre-existing.

The postulates of cell theory are:

1. All Living organisms are made of one or more cells.
2. The cell is the fundamental unit of structure and function in all living organisms.
3. The new cell is derived from pre-existing cells dividing into two by cell division.
4. The cell contains the hereditary material which is passed from generation to generation.



Mathias Jakob Schleiden



Theodor Schwann



Rudolf Virchow

Major contributors in the development of cell theory

Sub-cellular or Acellular Particles:

According to the first principle of the cell theory all organisms are composed of one or more cells.

Viruses, prions and viroids are not composed of cells rather they are sub-cellular or acellular particles but do not run any metabolic activity inside them. As they show some characteristics of living organisms i.e. they can increase in number and can transmit their characteristics to the next generations.

Cell:

Cells are the basic units of organisms and all tissues and organs are composed of cells. There are different types of cells. Cells can either be prokaryotic or eukaryotic. Eukaryotic cells have a proper nucleus and membrane bound organelles. Plant and animal cells are eukaryotes. Plant cells are generally a cubical shape while animal cells are usually spherical. Plant cells and animal cells have evolved different organelles to perform specific functions.

The activity of an organism depends on the total activity of independent cells. Energy flow occurs in cells through the breakdown of carbohydrates by respiration. Cells contain the information necessary for the creation of new cells. This information is known as 'hereditary information' and is contained within DNA. The contents of cells from similar species are basically the same.

DNA (the hereditary information of cells) is passed from 'parent' cells to 'daughter' cells during cell division.

Cells are the smallest form of life; the functional and structural units of all living things. Your body contains several billion cells, organized into over 200 major types, with hundreds of cell-specific functions.

Some functions performed by cells are so vital to the existence of life that all cells perform them (e.g. cellular respiration). Others are highly specialized (e.g. photosynthesis).

4.2.2 Comparison between Prokaryotes and Eukaryotes:

Organisms whose cells have a membrane bounded nucleus are called eukaryotes (from the Greek words **'Eu'** means well or truly and **'karyon'** means kernel or nucleus. Organisms whose cells do not have a membrane bounded nucleus are called prokaryotes (**'pro'** means before).

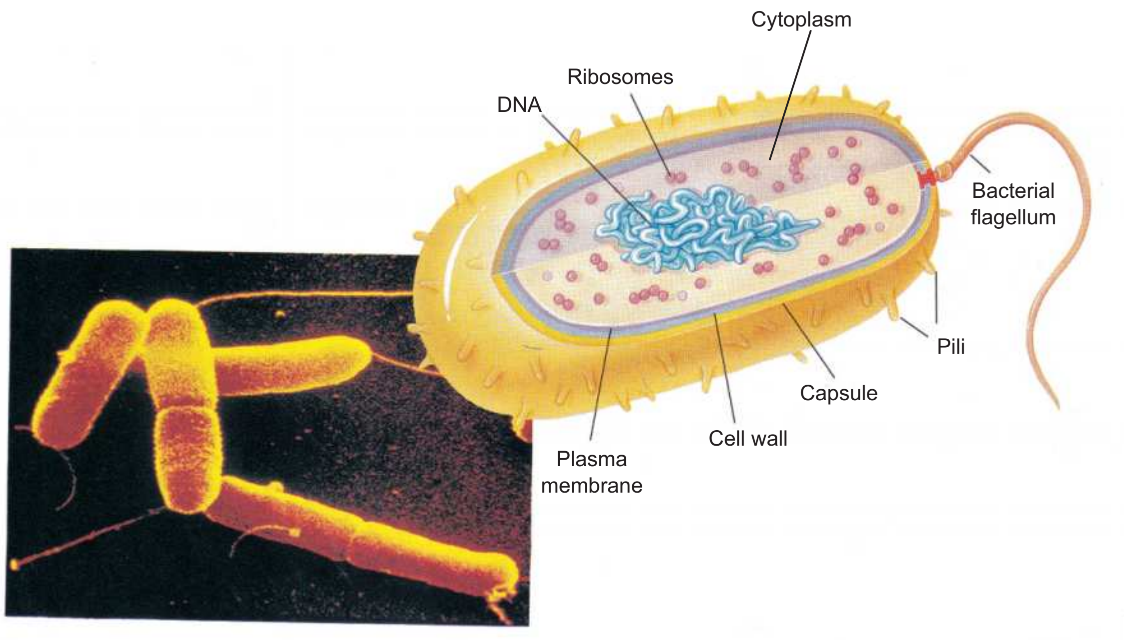


Figure 4.7 The structure of Bacterial Cell

Compare between prokaryotes and eukaryotes:

Cellular Structures	Prokaryotic cell	Eukaryotic cell
Example;	Bacteria and Cyanobacteria	Animals and plants
Nucleus	Without membrane	Membrane bounded
Number of chromosomes	One but not true chromosomes:	More than One
Number of cells	Unicellular	Unicellular and Multicellular
True membrane bound orgenelles	Absent	Present
Lysosomes and Peroxisome	Abscent	Present
Microtubules	Absent or rare	Present
Endoplasmic reticulum	Absent	Present
Mitochondria	Absent	Present
Ribosomes	Smaller 70S	Larger 80S
Vesicles	Present	Present
Golgi Apparatus	Absent	Present
Chloroplasts	Absent	Present (in plants)
Plasma membrane with steroid	Usually no	Yes
Permeability of nuclear membrane	Not present	Selective
Vacuoles	Absent	Present
Cell Size	1-10 µm	1-1000 µm
Flagella	Submicroscopic in size, composed of only one fiber	Microscopic in size; membrane bound

4.2.3 Cellular Structures and Functions:

We will now look at some of the basic cell structures and organelles in animal and plant cells. You will be noticed that there are key differences between plant and animal cells. The table below summarizes these differences.

Difference between animal and plant cell:

Animal Cells	Plants Cells
Do not contain plastids.	Almost all plants cells contain plastids such chloroplasts, chromoplasts and leucoplasts.
No cell wall.	Have a rigid cellulose cell wall in addition to the cell membrane.
Animals do not have plasmodesmata or pits.	Contain plasmodesmata and pits.
Few vacuoles (if any).	Large central vacuole filled with cell sap in mature cells.
Nucleus is generally found at the centre of the cytoplasm.	Nucleus is found near the edge or periphery of the mature cell.
Animal cells possess lysosomes which contain enzymes that digest cellular macromolecules.	Plant cells rarely contain lysosomes as the plant vacuole handles molecule degradation.
Animal cells contain these cylindrical structures that organize the assembly of microtubules during cell division.	Plant cells do not typically contain centrioles.

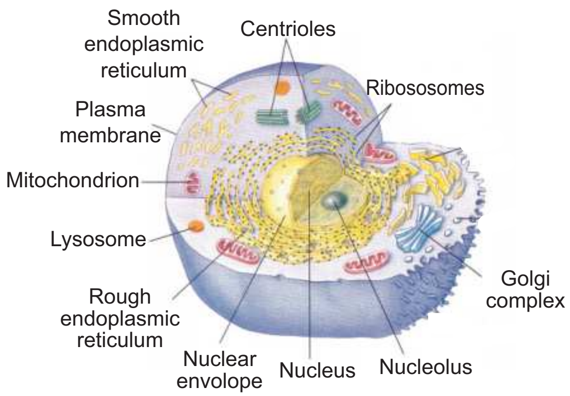


Figure 4.8 Animal cell

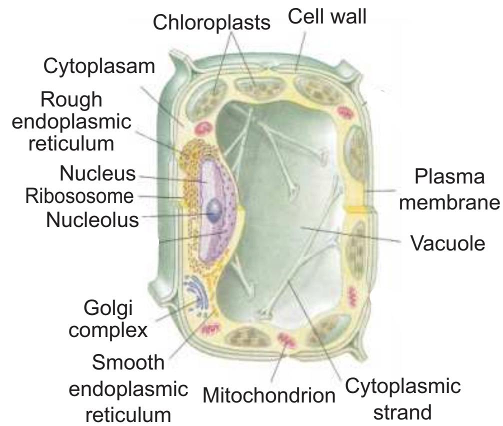


Figure 4.9 Plant cell

1. Cell wall:

A cell wall is a tough, rigid non-living and permeable protective layer in some cell types. This outer covering is positioned next to the cell membrane (plasma membrane) in plant cells, fungi, algae and bacteria. The cell wall has many important functions in a cell including protection, structure, and support.

Cell wall composition varies depending on the organism. In plants, the cell wall is composed mainly of strong fibers of cellulose. Bacterial cell walls are composed of a sugar and amino acid called peptidoglycan. The main components of fungal cell walls are chitin, glucans, and proteins.

In plants, the wall is composed of cellulose. It may consist up to three layers that help to support the plant. These layers include the middle lamella, the primary cell wall and the secondary cell wall.

Middle lamella: It separates one cell from another. It is a thin membranous layer on the outer side of the cell and is made of a sticky substance called pectin and cellulose.

Primary cell wall: It lies on the inside of the middle lamella and is mainly composed of cellulose.

Secondary cell wall: It lies along side the cell membrane. It is made up of a thick and tough material of cellulose which is held together by a hard, water proof substance called lignin. It is only found in cells which provide mechanical support in plants, i.e., Some cells of xylem like tracheid and vessels.

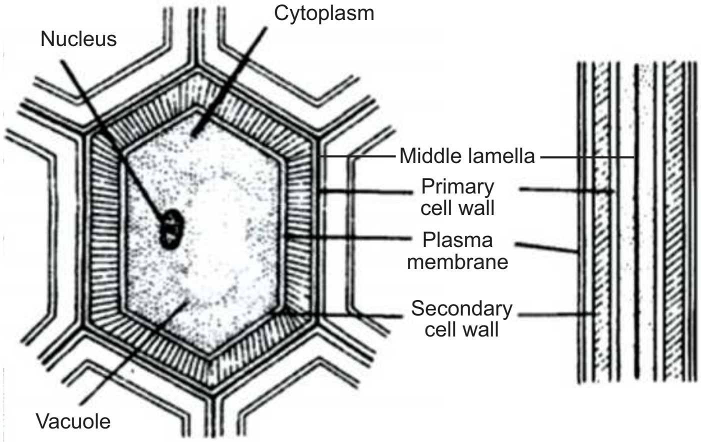


Figure 4.10 (a) Structure of cell wall

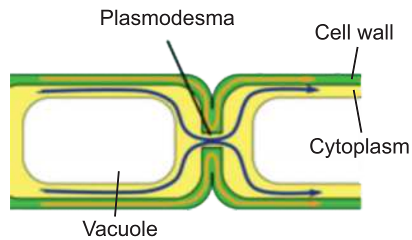


Figure 4.10 (b)
Cell wall showing plasmodesma

The openings in the cell wall are called **plasmodesmeta** which contain strands of cytoplasm that connect adjacent cells. This allows cells to interact with one another, allowing molecules to travel between plant cells.

The main function of the wall is to protect the inner parts of the plant cell, it gives plant cells a more uniform and regular shape and provides support for the plant body. The cell wall is completely permeable to water and mineral salts which allows distribution of nutrients throughout the plant.

2. Cell membrane:

The cell membrane is the outer most living boundary of all cells. The cell membrane, also called the plasma membrane, physically separates the intracellular space (inside the cell) from the extracellular environment (outside the cell). The cell membrane surrounds and protects the cytoplasm.

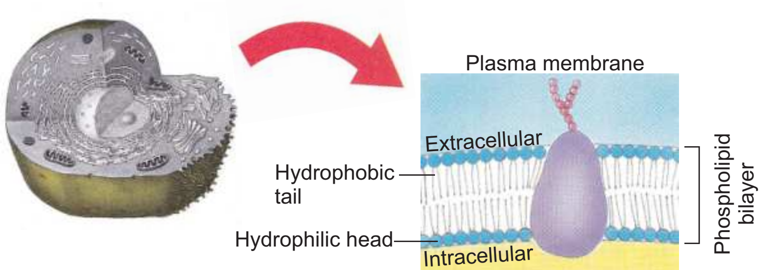


Figure 4.11 Cell membrane showing arrangment of phospholipid molecules in bilayers

The cell membrane is composed of a double layer (bilayer) of special lipids called phospholipids.

4.2.4 Structure of the cell membrane – the fluid mosaic model:

S.J. Singer and ***G.L. Nicolson*** proposed the Fluid Mosaic Model of the cell membrane in 1972. This model describes that phospholipid acting like matrix and conjugated glycoproteins (glucose and protein together) may float freely in this matrix.

This model describes the structure of the cell membrane as a fluid structure with various protein and carbohydrate components floating freely in the membrane. All the exchanges between the cell and its environment have to pass through the cell membrane. The cell membrane is selectively permeable to ions (e.g. hydrogen, sodium), small molecules (oxygen, carbon dioxide) and larger molecules (glucose and amino acids) and controls the movement of substances in and out of the cells. It performs many important functions within the cell such as osmosis, diffusion, transport of nutrients into the cell, processes of ingestion and secretion.

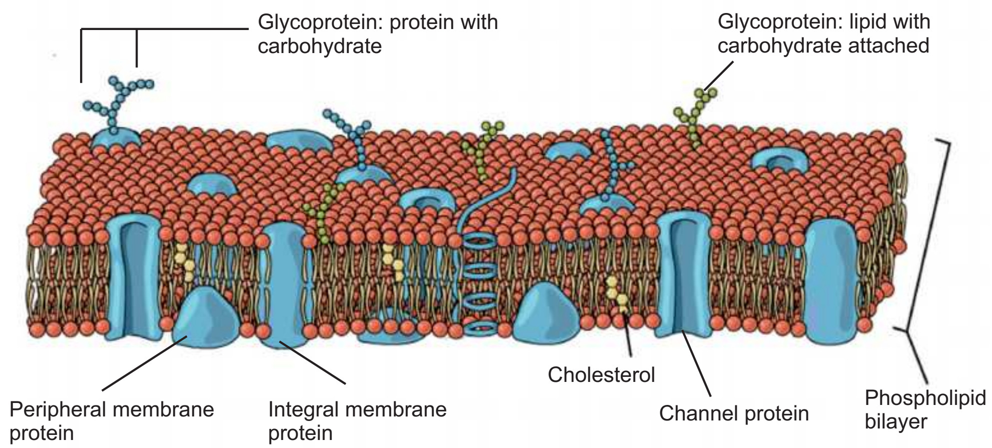


Figure 4.12 Section of cell-membrane

Movement across the membranes:

Movement of substances across cell membranes is necessary as it allows cells to acquire oxygen and nutrients, excrete waste products and control the concentration of required substances in the cell (e.g oxygen, water, hormones, ions, etc). This movement occurs by diffusion, osmosis, facilitated diffusion and active transport.

1. Diffusion:

Diffusion is the movement of substances from a region of high concentration to low concentration. It is therefore said to occur down a concentration gradient.

Diffusion is a passive process which means it does not require any energy input. It can occur across a living or non-living membrane and can occur in a liquid or gas medium. Examples diffusion of carbon dioxide, oxygen, water and other small molecules that are able to dissolve within the lipid bilayer.

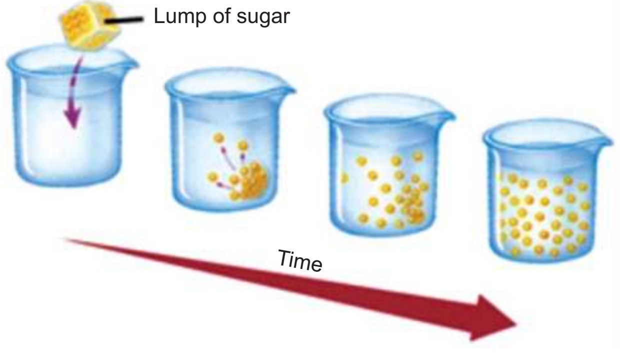


Fig 4.13 Diffusion:
The diagram shows the movement of dissolved particles within a liquid until eventually becoming randomly distributed.

2. Osmosis:

Movement of water always occurs down a concentration gradient, i.e., from dilute solution to concentrated solution. Osmosis is also a passive process and does not require any input of energy. Cell membranes allow molecules of water to pass through, but they do not allow molecules of most dissolved substances, e.g. salt and sugar, to pass through it.

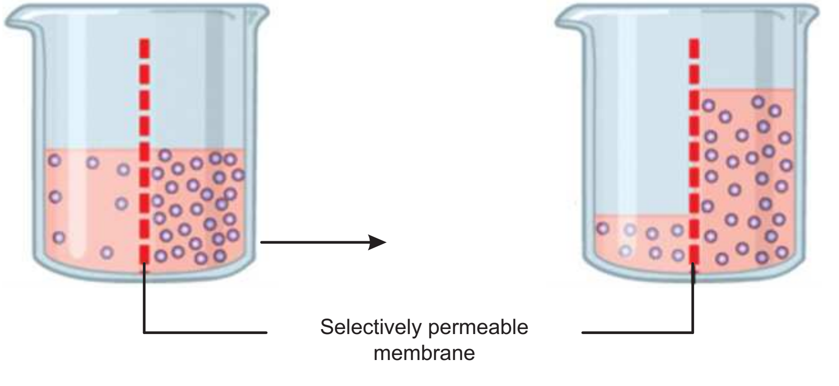


Fig 4.14 Osmosis

In biological systems, osmosis is vital to plant and animal cell survival. Figure 4.15 demonstrates how osmosis affects red blood cells and plant cell, when they are placed in three different solutions with different concentrations.

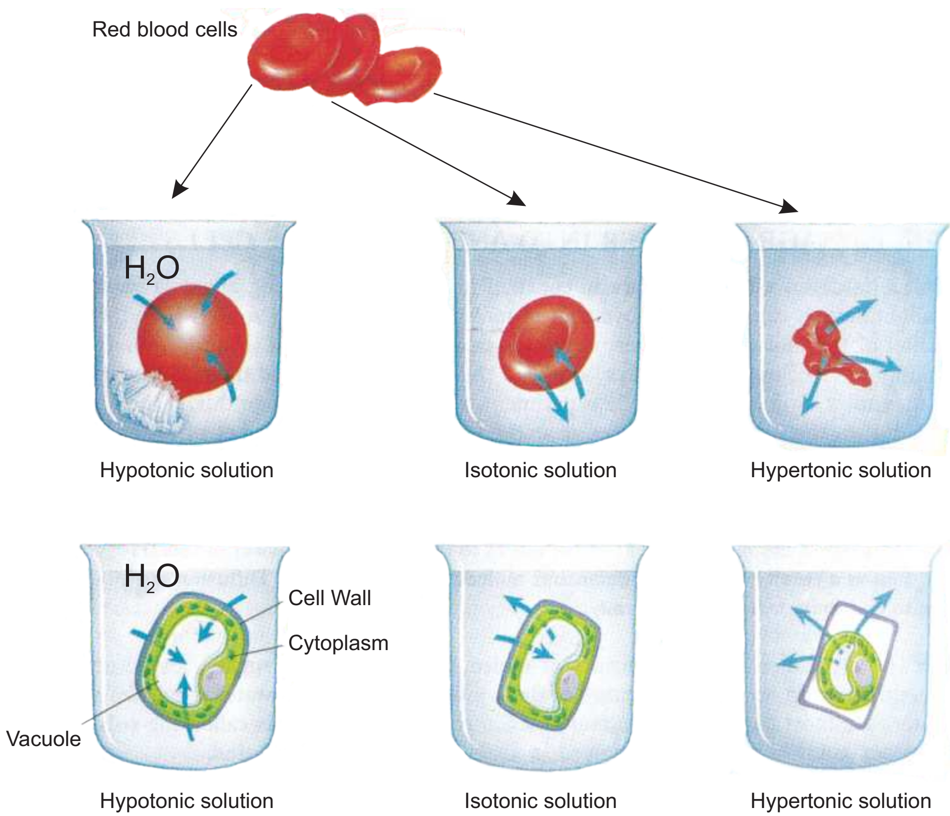


Figure 4.15 The effect of hypertonic, isotonic and hypotonic solutions on red blood cells and plant cell.

Plant cells use osmosis to absorb water from the soil and transport it to the leaves. In hypertonic conditions a plant cell loses water and cytoplasm shrinks and shrinkage of cytoplasm is called **plasmolysis**. Osmosis in the kidneys keeps the water and salt levels in the body and blood at the correct levels.

Activity: Predicting the direction of osmosis

Apparatus:

- Beaker
- Large potato
- Potato peeler/scalpel
- Pins
- Concentrated sucrose/sugar solution. To obtain this, add 100g of sugar to 200ml of water.

Procedure:

1. Peel off the skin of a large sized potato with a scalpel/potato peeler.
2. Cut its one end to make the base flat.
3. Make a hollow cavity in the potato almost to the bottom of the potato.
4. Add the concentrated sugar solution into the cavity of the potato, filling it about half way. Mark the level by inserting a pin at the level of the sugar solution (insert the pin at an angle into the cavity at the level) (A).
5. Carefully place the potato in the beaker containing water.
6. Observe what happens to the level of the sugar solution in the potato.
7. After 15 to 20 minutes, mark the level by inserting the second pin at the level of the sugar solution (insert as the first pin) (B).

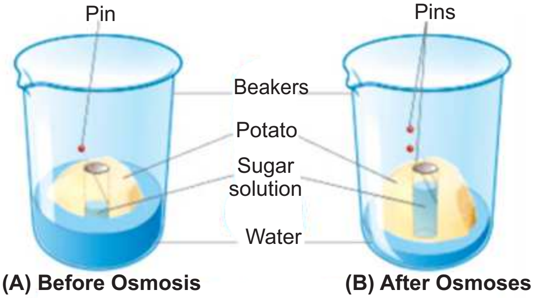


Figure 4.16 Potato Osmoscope

Questions

1. What do you observe happening to the level of the solution inside the potato?
2. What conclusion can you draw based on your observation?
3. What conditions were met in this experiment that makes this type of transport different to diffusion?

3. Facilitated diffusion:

Facilitated diffusion is a special form of diffusion which allows rapid exchange of specific substances. Particles are taken up by carrier proteins which change their shape as a result. The change in shape causes the particles to be released on the other side of the membrane.

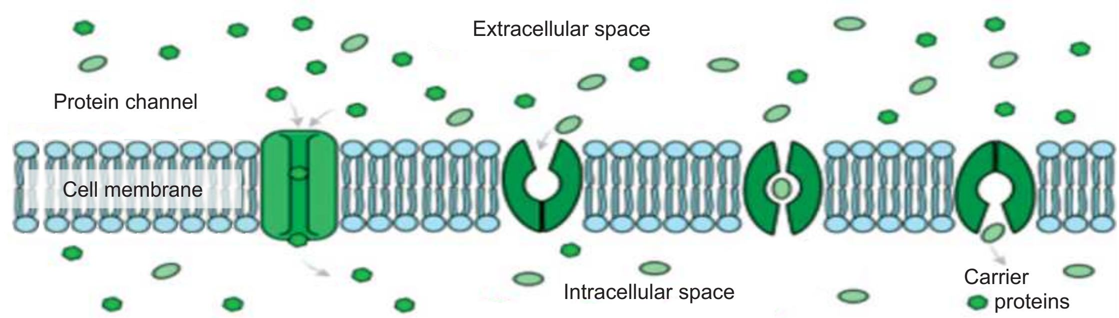


Figure 4.17 Facilitated diffusion in cell membrane, showing ion channels and carrier proteins

4. Active transport:

Active transport is the movement of substances against a concentration gradient, from a region of low concentration to high concentration using an input of energy. In biological systems, the form in which this energy occurs is adenosine triphosphate (ATP). Examples of substances moved include sodium and potassium ions as shown in Figure 4.18.

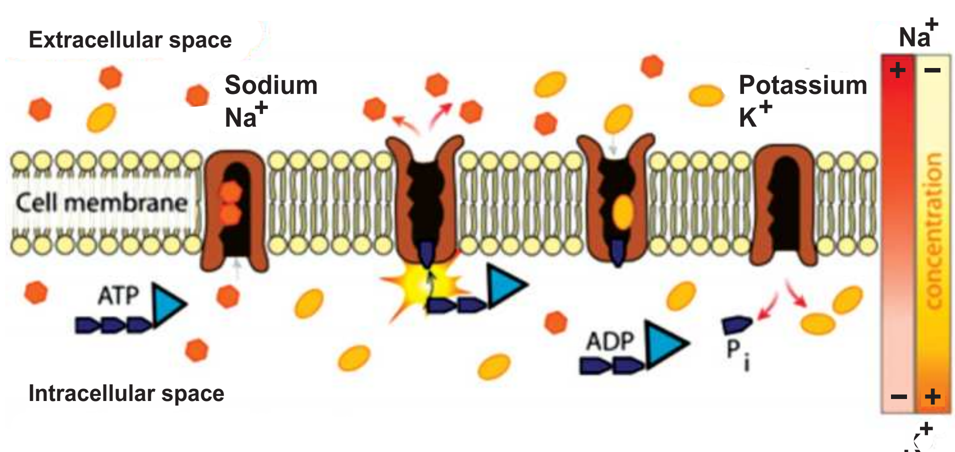


Figure 4.18 The sodium-potassium pump is an example of primary active transport.

ATP and ADP are molecules involved with moving energy within cells.

Cell organelles: We will now look at the key organelles that make up the cell. It is important to bear in mind that structure and function are closely related in all living systems. When studying each organelle, ensure that you observe the specific structures (from micrographs) that allow the organelle to perform its specific function.

Cytoplasm: The cytoplasm is the jelly-like substance that fills the cell. It consists of up to 90% water. It also contains dissolved nutrients and waste products. Its main function is to hold together the organelles which make up the cytoplasm. It also nourishes the cell by supplying it with salts and sugars and provides a medium for metabolic reactions to occur.

Cytoskeleton: A microscopic network of protein consists of microtubules and various filaments that spread out through the cytoplasm, providing both structural support and means of transport within the cell. Microtubules are made of tubulin while filaments made up of active protein.

Nucleus: The nucleus is the largest organelle in the cell and contains the entire cell's genetic information in the form of DNA. The presence of a nucleus is the primary factor that distinguishes eukaryotes from prokaryotes. Nucleus is covered by two phospholipids membranes known as nuclear envelope that separates the nucleus and its contents from the cytoplasm. Nuclear pores are found in the nuclear envelope and help to regulate the exchange of materials (such as RNA and proteins) between the nucleus and the cytoplasm. Inside nuclear envelope, a granular fluid is present called **nucleoplasm**. In nucleus an aggregation of RNA is also present called nucleolus. In non-dividing cell the genetic material is found in the form of net work in the nucleus called chromatin net work.

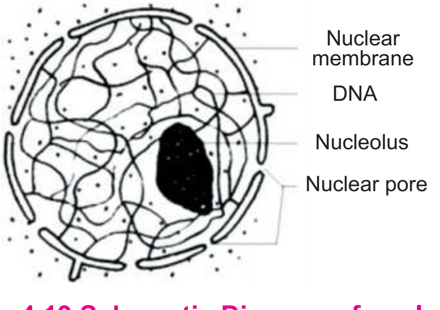


Figure 4.19 Schematic Diagram of nucleus

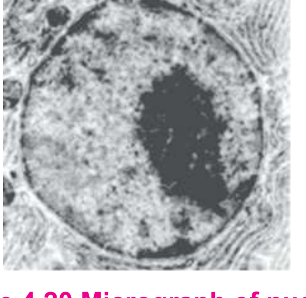


Figure 4.20 Micrograph of nucleus

Mitochondria (Singular; Mitochorion):

A mitochondrion is a membrane bound organelle found in eukaryotic cells. Mitochondria contain two phospholipid bilayers: there is an outer membrane, and an inner membrane. The inner membrane contains many folds called cristae which contain specialized membrane proteins that enable the mitochondria to synthesize ATP. Inside the inner membrane is a jelly-like matrix. The compartment, the compartments of the mitochondrion are shown in figure 4.21

Mitochondria is the site of aerobic respiration. During aerobic respiration energy is produced in the form of ATP. Therefore the Mitochondria is also called 'Power house' of cell.

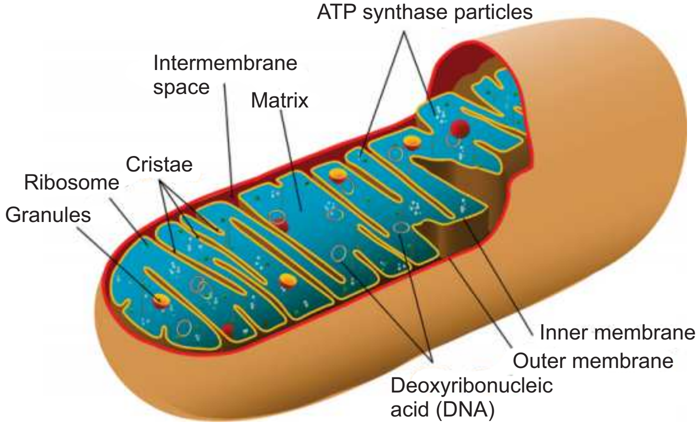


Figure 4.21 Mitochondria

Endoplasmic reticulum:

The endoplasmic reticulum (ER) is an organelle found in eukaryotic cells only. The ER has a double membrane consisting of a network of hollow tubes, flattened sheets, and round sacs. These flattened, hollow folds and sacs are called cisternae. The ER is located in the cytoplasm and is connected to the nuclear envelope. There are two types of endoplasmic reticulum: smooth and rough ER.

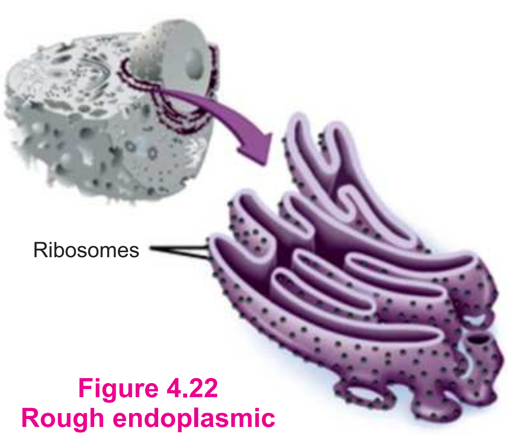


Figure 4.22 Rough endoplasmic reticulum

Smooth Endoplasmic Reticulum: does not have any ribosomes attached. It is involved in the synthesis of lipids, including oils, phospholipids and steroids. It is also responsible for metabolism of carbohydrates, regulation of calcium concentration and detoxification.

Rough Endoplasmic Reticulum: is covered with ribosomes giving the endoplasmic reticulum its rough appearance. It is responsible for protein synthesis and plays a role in membrane production. The folds present in the membrane increase the surface area allowing more ribosomes to be present on the ER, thereby allowing greater protein production.

Ribosomes:

Ribosomes are composed of RNA and protein. They occur in the cytoplasm and are the sites where protein synthesis occurs. Ribosomes may occur singly in the cytoplasm or in groups or may be attached to the endoplasmic reticulum thus forming the rough endoplasmic reticulum.

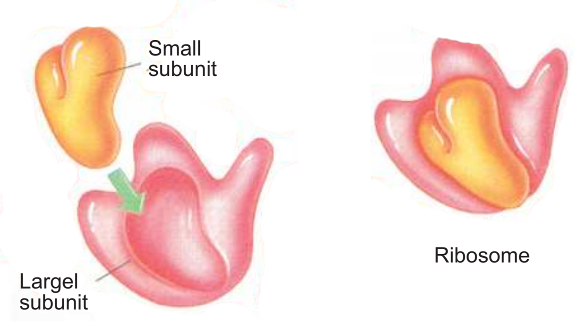


Figure 4.23
Structure of Ribosome

Golgi body:

The Golgi body was discovered by the Italian physician Camillo Golgi. It was one of the first organelles to be discovered and described in detail because its large size made it easier to observe. It is important for proteins to be transported through Golgi body from where they are synthesized to where they are required in the cell. The Golgi body is the sorting organelle of the cell.

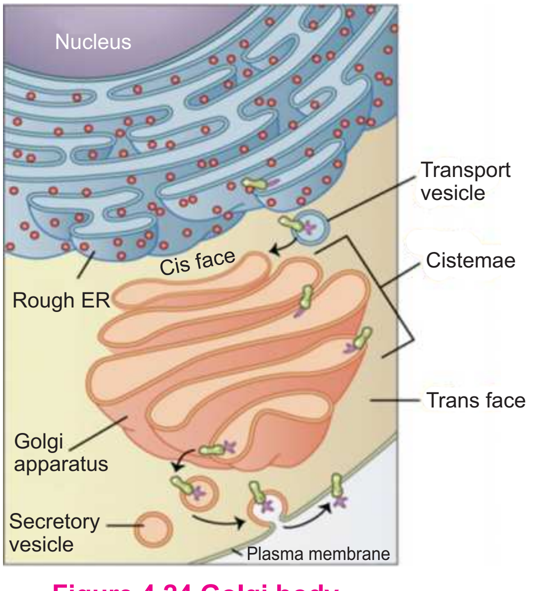


Figure 4.24 Golgi body

The Golgi body consists of a stack of flat membrane-bound sacs called cisternae. The cisternae within the

Golgi body consist of enzymes which modify the packaged products of the Golgi body.

Proteins are transported from the rough endoplasmic reticulum (RER) to the Golgi. In the Golgi, proteins are modified and packaged into vesicle. The Golgi body therefore receives proteins made in one location in the cell and transfers these to another location within the cell where they are required. For this reason the Golgi body can be considered to be the 'post office' of the cell.

Vesicles and lysosomes:

Vesicles are small, membrane-bound spherical sacs which facilitate the metabolism, transport and storage of molecules. Many vesicles are made in the Golgi body and the endoplasmic reticulum, or are made from parts of the cell membrane. Vesicles can be classified according to their contents and function. Transport vesicles transport molecules within the cell.

Lysosomes are formed by the Golgi body and contain powerful digestive enzymes that can potentially digest the cell. These powerful enzymes can digest cell structures and food molecules such as carbohydrates and proteins. Lysosomes are abundant in animal cells that ingest food through food vacuoles. When a cell dies, the lysosome releases its enzymes and digests the cell.

Vacuoles:

Vacuoles are fluid-filled spaces that occur in the cytoplasm of plant cells, but are very small or completely absent in animal cells. Plant cells generally have one large vacuole that takes up most of the cell's volume in mature cell. A selectively permeable boundary called the tonoplast, surround the vacuole. The vacuole contains cell sap which is a liquid consisting of water, mineral salts, sugars and amino acids. The vacuole plays an important role in hydrolysis, excretion of cellular waste, storage of water, organic and inorganic substances.

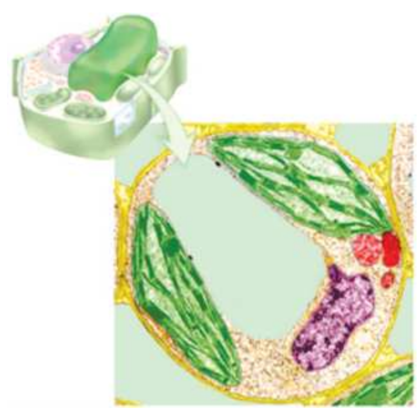


Figure 4.25 A vacuole

Centrioles:

Animal cells contain a special organelle called a centriole. The centriole is a cylindrical tube-like structure that is composed of 27 microtubules arranged in a very particular pattern of triplets in rows. The site where two centrioles arranged perpendicular to each other are referred to as a centrosome. The centrosome plays a very important role in cell division. The centrioles are responsible for organizing the microtubules that position the chromosomes in the correct location during cell division.

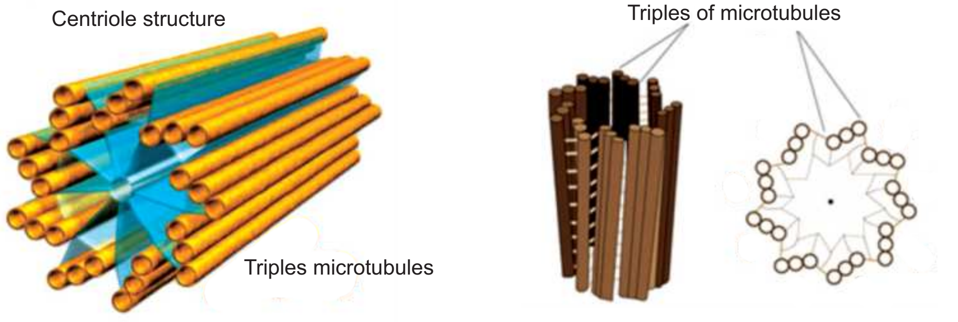


Figure 4.26 Centriole side view and pattern

Plastids

Plastids are large cytoplasmic and major organelles found in the cells of plants and algae. Plastids are the site of manufacture and storage of important chemical compounds used by the cell. Plastids often contain pigments used in photosynthesis, and the types of pigments present can change or determine the cell's colour. There are three different types of plastids:

Chloroplasts: Green-coloured plastids found in plants and algae.

Chromoplasts: Contain red, orange or yellow pigments and are common in ripening fruit, flowers or autumn leaves.

Leucoplasts: Colour less plastids.

The colour of plant flowers such as an orchid is controlled by a specialized organelle in a cell known as the chromoplast.

Chloroplast

The chloroplast is a double-membraned organelle. Within the double membrane is a gel-like substance called stroma. Stroma contains enzymes for photosynthesis. Suspended in the stroma are stack-like structures called grana (singular = granum). Each granum is a stack of thylakoid discs. The chlorophyll molecules (green pigments) are found on the surface of the thylakoid discs. Chlorophyll absorbs energy from the sun for photosynthesis.

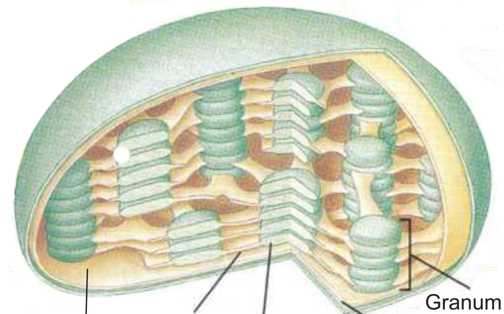


Figure 4.27 Structure of choloroplast

4.3 CELL SIZE AND SHAPE AS THEY RELATE TO SURFACE AREA TO VOLUME RATIO

Cells are microscopic mostly because of this constraint; there are some physiological limits to how big a cell can grow. The scale, or size of a cell compared to other objects, is incredibly small.

The smallest cells are bacteria called mycoplasmas, with diameter between 0.1 μm to 1.0 μm. The bulkiest cells are bird eggs, and the longest cells are some muscle cells and nerve cells. Most cells lie between these extremes. Cell size and shape are related to cell function. Bird eggs are bulky because they contain a large amount of nutrient for the developing young. Long muscle cells are efficient in pulling different body parts together. Lengthy nerve cells can transmit messages between different parts of body. On the other hand, small cell size also has many benefits. For example human red blood cells are only 8 μm in diameter and therefore can move through our tiniest blood vessels i.e. capillaries. Most cells are small in size. In relation of their volumes, large cells have less surface area as compared to small cells. Figure 4.28 Shows this relationship using cube-shaped cells. The figure shows 1 large cell and 27 small cells. In both cases, the total volume is same:

Volume = 30 μm X 30 μm X 30 μm = 27,000 μm^3

In contrast to the total volume, the total surface areas are very different. Because a cubical shape has 6 sides, its surface area is 6 times the area of 1 side.

The surface areas of cubes are as follows:

Surface area of 1 large cube = 6 X (30 µm X 30 µm) = 5400 μm^2

Surface area of 1 small cube = 6 X (10 µm X 10 µm) = 600 μm^2

Surface area of 27 small cubes = 27 X 600 μm^2 = 16, 200 μm^2

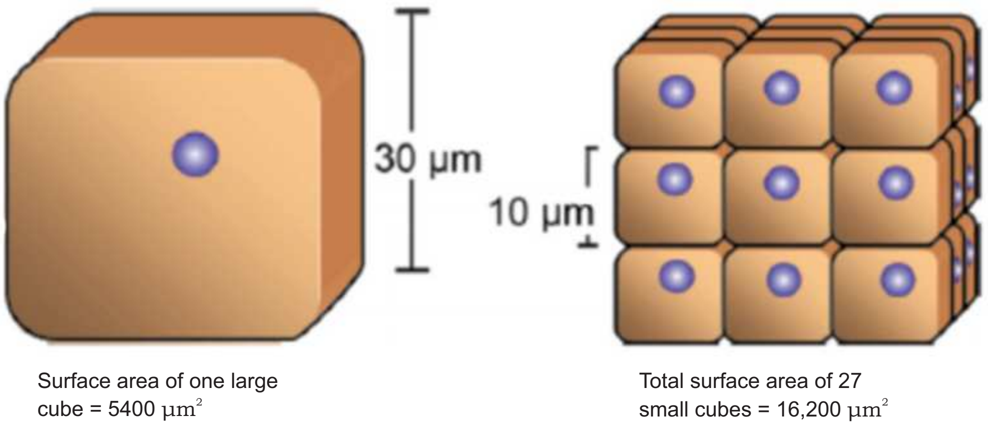


Figure 4.28 Surface-area to volume ratio too small = decreased rate of chemical exchange → cell dies

Cell size and volume ratio:

Waste production and demand of nutrients are directly proportional to cell volume. Cell takes up nutrients and excretes wastes through its surface cell membrane. So a large volume cell demands large surface area but as the figure shows, a large cell has a much smaller surface area relative to its volume than smaller cells have. Each internal region of the cell has to be served by part of the cell surface. As a cell grows bigger, its internal volume enlarges and the cell membrane expands. Unfortunately, the volume increases more rapidly than does the surface area, and so the relative amount of surface area available to pass materials to a unit volume of the cell steadily decreases. Hence we conclude that the membranes of small cells can serve their volumes more easily than the membrane of a large cell.

> In Life Sciences it is important to note that whenever a structure has an increased surface area, there is an increase in the functioning of that structure.

Activity 1: Examining plant cells under the microscope

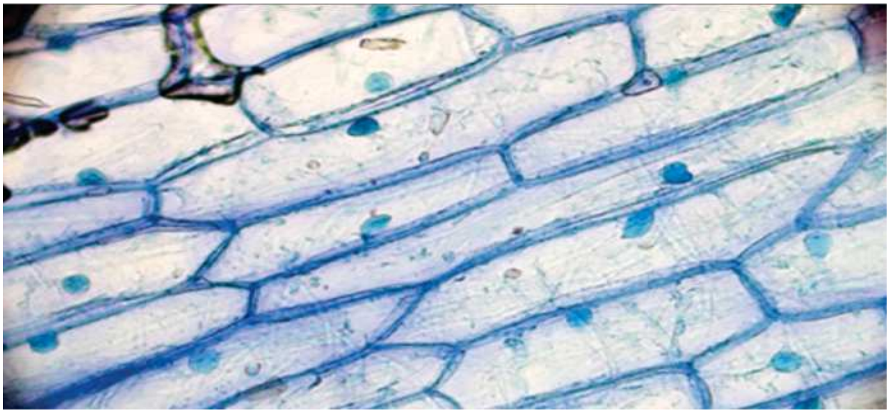
To study the microscopic structures of plant cells.

Apparatus:

- Onion
- Brushes
- Forceps
- Watch glass
- Blade
- Tissue paper
- Dropper
- Petri dish containing water
- Slides and coverslips
- Compound microscope
- Iodine solution

Procedure:

1. Peel off the outer most layer of an onion carefully, using a pair of forceps.
2. Place the peeled layer in a watch glass containing water. Make certain that the onion peel does not roll or fold.
3. Using a scalpel or a thin blade, cut a square piece of the onion peel (about $1cm^2$).
4. Remove the thin transparent skin from the inside curve of a small piece of raw onion and place it on a drop of iodine solution on a clean slide.
5. Cover the peel with a coverslip ensuring that no bubbles are formed.
6. Using a piece of tissue paper wipe off any excess iodine solution remaining on the slide.
7. Observe the onion skin under low power of the microscope and then under high power.
8. Draw a neat diagram of 5-10 cells of the typical cells you can see.



Onion cells stained with methylene blue.

Activity 2: Examining animal cells under the microscope

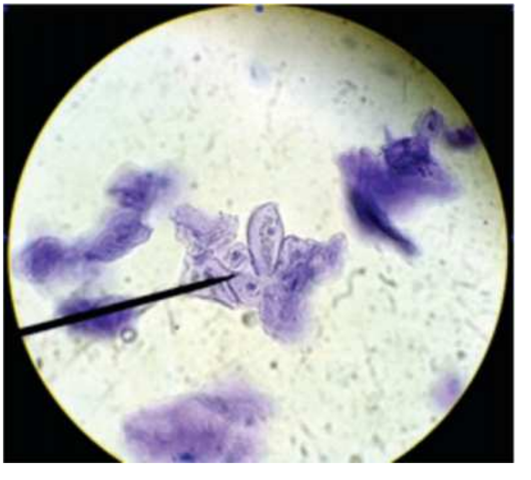
To study the microscopic structures of human cheek cells under a compound microscope.

Apparatus:

- Cotton bud
- Dropper
- Forceps
- Clean slide
- Water
- Microscope
- Methylene blue
- Tissue paper

Procedure:

1. Place a drop of water on a clean glass slide.
2. Using a clean ear bud, wipe the inside of your cheek. The ear bud will collect a moist film.
3. Spread the moist film on a drop of water on a clean glass slide, creating a small smear on the slide.
4. Use a coverslip to cover the slide gently.
5. Place one or two drops of stain on the side of the cover slip.
6. Use a piece of tissue to remove the excess dye.
7. Observe the cheek cells under low power magnification and then under high power magnification.



Cheek epithelial cells

Questions

1. What are the shapes of epidermal cells of the onion peel and the human cheek cells?
2. Why is iodine used to stain the onion peel?
3. What is the difference between the arrangement of cells in onion cells and in human cheek cells?
4. Why is a cell considered the structural and functional unit of living things?

4.4 ANIMAL AND PLANT TISSUES

We know the levels of organization where a group of similar cells that work together to perform a common function is known as a tissue. For instance, the cells in the small intestine that absorb nutrients look very different from the muscle cells needed for body movement.

(A) Animal tissues:

Humans and other large multicellular animals are made up of four basic types tissue: **epithelial** tissue, **connective** tissue, **muscular** tissue and **nervous** tissue.

1. Epithelial tissue:

Epithelial tissue covers the surface of the body, lines the spaces inside the body and forms glands. For instance, the outer layer of your skin is an epithelial tissue and the lining of small intestine are made up of epithelial tissues.

Epithelial cells are polarized, means that they have a top and a bottom side.

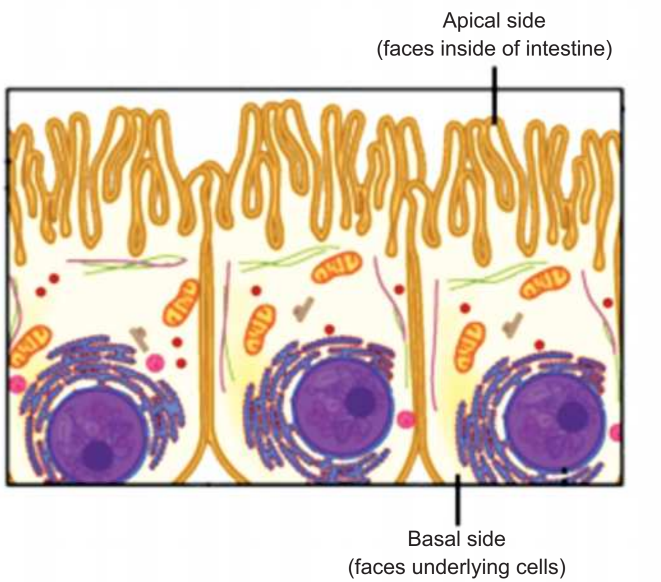
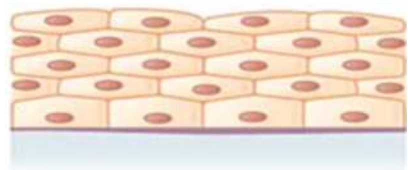
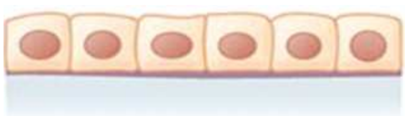
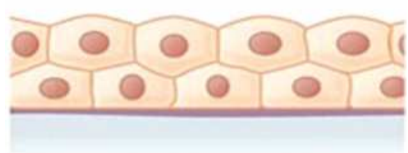
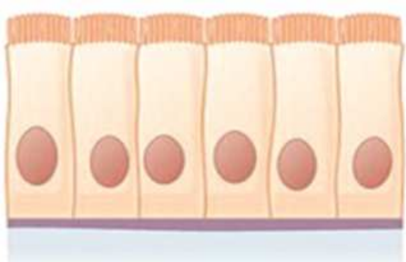
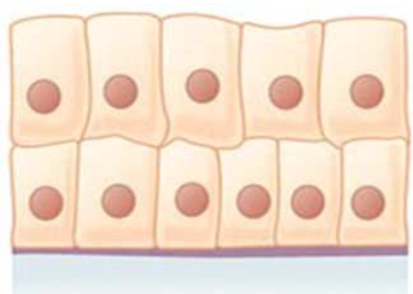


Figure 4.29 Epithelial tissue

There are different types of epithelial tissue depending on their function in a particular location. The simplest classification of these tissues is based on the number of cell layers.

When the epithelium is composed of a single layer of cells, it is called **simple epithelial tissue** and those containing two or more layers of cells are called **stratified epithelial tissues**.

	Simple	Stratified
Squamous	 Simple squamous spithelium	 Startified squamous epithelium
Cubical	 Simple cuboidal epithelium	 Stratified cuboidal epithelium
Columnar	 Simple columnar epithelium	 Stratified columnar epithelium

Simple squamous epithelium is found in the alveoli of lungs, and its structure is important for the exchange of gases between the blood and lungs. **Simple cuboidal epithelia** line the lumen of collecting ducts in the kidney and are present in the thyroid gland around the follicles that secrete thyroid hormones.

Simple columnar epithelia are found in the female reproductive system and in the digestive tract.

Stratified epithelia consist of more than one layer of cells and only one layer is in direct contact with the basement membrane.

Stratified squamous epithelia are found in skin, with many dead, keratinized cells providing protection against water and nutrient loss. **Stratified cuboidal epithelia** are found surrounding the ducts of many glands, including mammary glands in the breast and salivary glands in the mouth. **Stratified columnar epithelia** are rare, found predominantly in some organs of the reproductive system. **Transitional epithelia** are a special subset of stratified epithelia. They are exclusively found in the excretory system.

2. Connective tissue:

This tissue which connects or bind the different types of cells called connective tissues. They also bind other tissues of the body with each other. Connective tissue holds structures in the body together, such as tendons.

Cartilage is a type of supporting connective tissue. It is a dense connective tissue. Cartilage has limited ground substance and can range from semisolid to a flexible matrix.



Figure 4.30 Cartilage presant in pina of ear

Bone is another type of supporting connective tissue. Bone can either be compact (dense) or spongy (cancellous), and contains the osteoblasts or osteocytes cells.

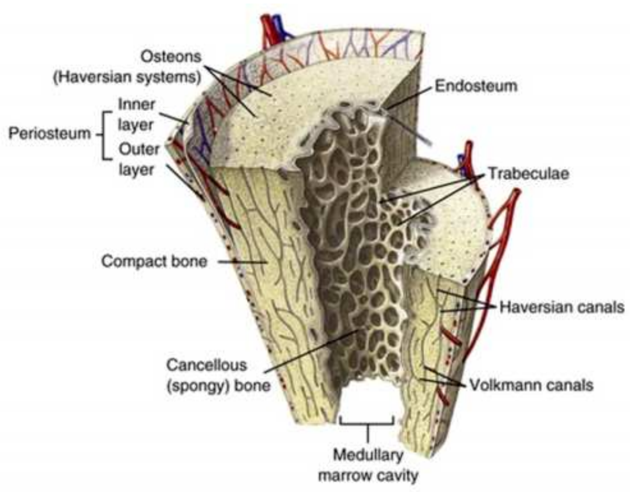


Figure 4.31 Longitudinal section of bone

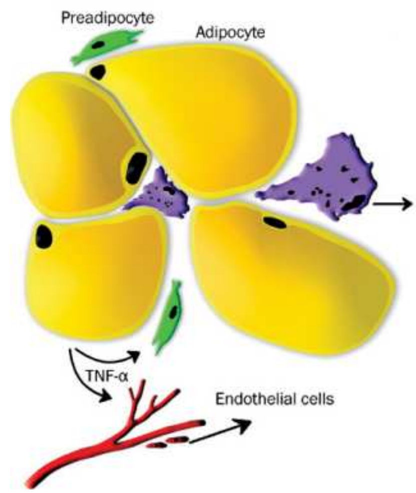


Figure 4.32 Adipose tissue

Adipose is another type of supporting connective tissue that provides cushions and stores excess energy and fat.

Blood referred to as connective tissue. It is a type of fluid connective tissue.

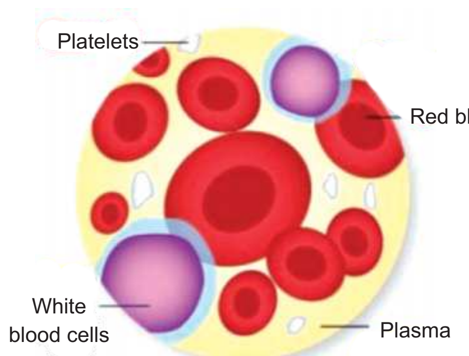


Figure 4.33 Blood cells

3. Muscle tissues:

Muscle tissue contains the cells that are responsible for the contraction of muscles. There are three types of muscular tissues i.e. cardiac, smooth, and skeletal.

Skeletal muscle, which is also called striated (striped) muscle, is what we refer to as muscle in everyday life. Skeletal muscle is attached to bones by tendons. For instance, the muscles in your legs and your arms are skeletal muscle.

Cardiac muscle is found only in the walls of the heart. Like skeletal muscle, cardiac muscle is striated, or striped. But it's not under voluntary control, so thankfully! you don't need to think about making your heart beat.

Smooth muscle is found in the walls of blood vessels, as well as in the walls of the digestive tract, the uterus, the urinary bladder, and various other internal structures. Smooth muscle is un-striped, (unstriated), it is involuntary, not under conscious control. That means you don't have to think about moving food through your digestive tract!

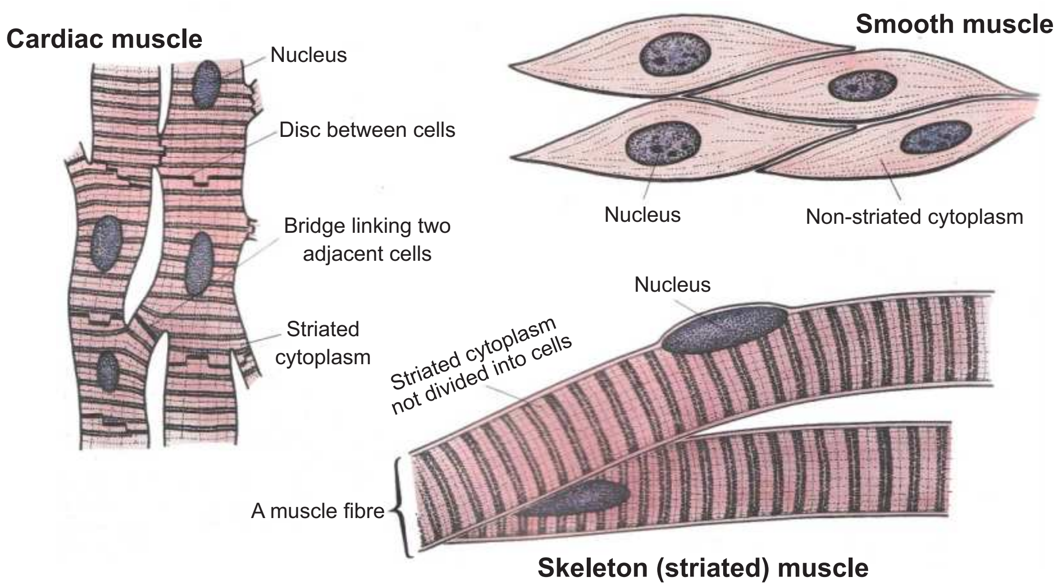


Figure 4.34 Types of msucles

4. Nervous tissues:

Nervous tissue is composed of neurons, which transmit information to other cells. Nervous tissue is found in the brain, spinal cord, and nerves. It is responsible for coordinating and controlling many body activities. It stimulates muscle contraction, creates an awareness of the environment, and plays a major role in emotions, memory, and reasoning. To do all these things, cells in nervous tissue need to be able to communicate with each other by way of electrical nerve impulses.

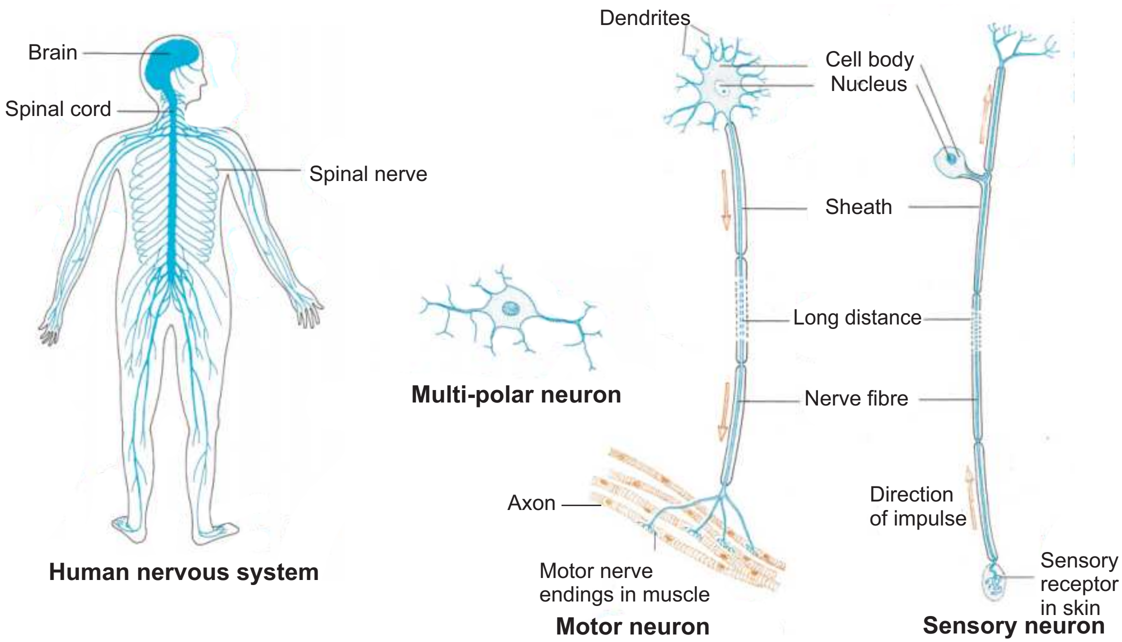
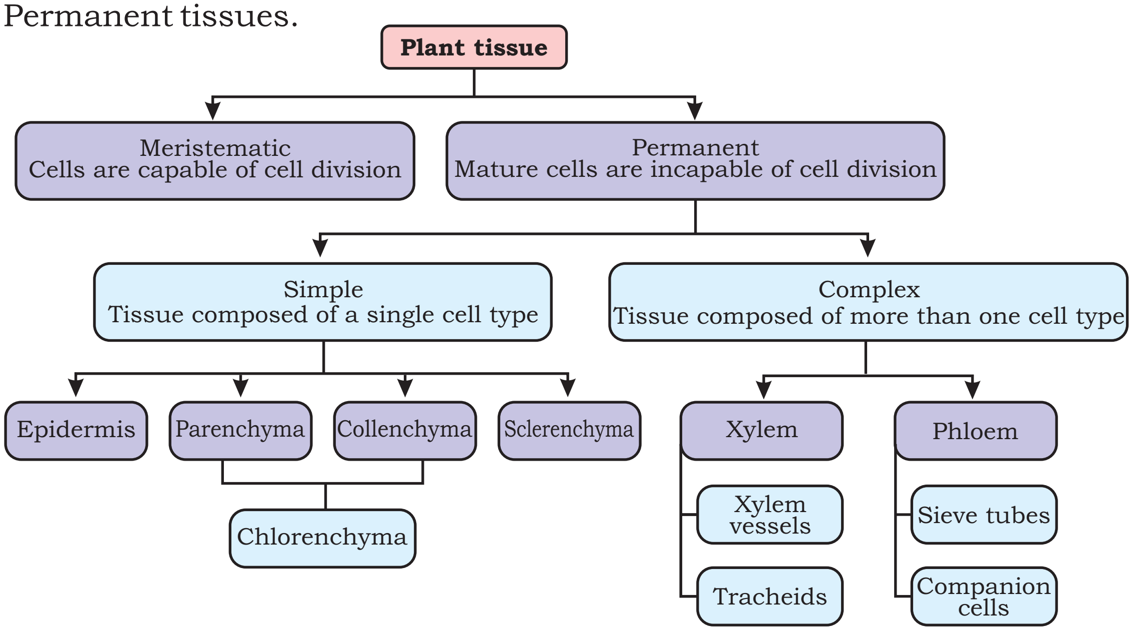


Figure 4.35 Human nervous system and various types of neuron cells

(B) Plant tissues

As same in animals, plant cells are grouped into tissues with characteristic functions such as photosynthesis, transport etc. There are two major categories of tissues in plants i.e. Meristematic tissues and Permanent tissues.



1. Meristematic Tissues:

These tissues are composed of cells, which have the ability to divide. The cells are thin walled, have large nucleus and number of small vacuoles. Usually they do not have inter-cellular spaces, so the cells are arranged compactly.

Two main types of meristematic tissues are recognized in plants.

(i) **Apical meristems** tissues are present at the apex of roots and stems. According to their position they are Apical meristems. Stem and root increase in length by the division of cells of these tissues. This type of growth is called **primary growth**.

(ii) **Lateral meristems** are located on the lateral sides of roots and shoot. By dividing, they are responsible for increase in grith of plant parts. This growth is called secondary growth.

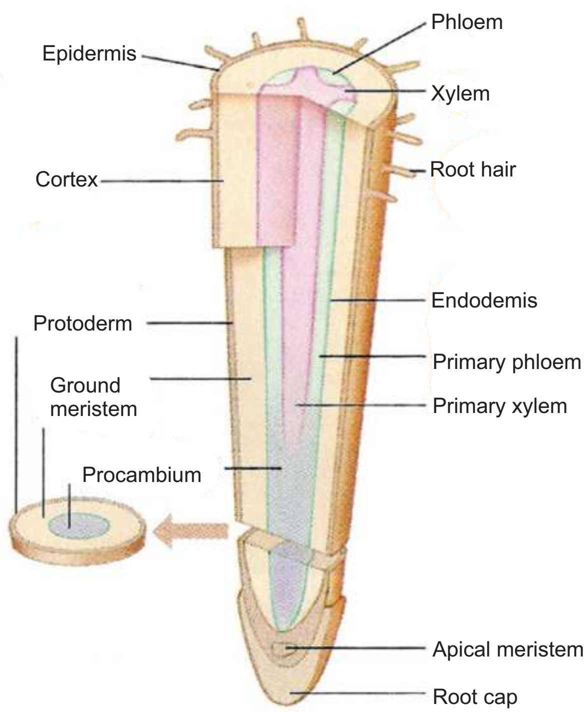


Figure 4.36 *Apical meristem at root tip, Vascular and cork cambium*

2. Permanent Tissues :

Permanent tissues originate from meristematic tissue. The cells of these tissues do not have the ability to divide and may have intercellular spaces in between cells. They are further classified into following types: either on the basis of position or composition. There are two types of permanent tissues i.e. (a) Simple permanent tissue (b) Compound or complex tissue.

(A) Simple permanent tissue:

Simple permanent tissues are made up of only one type of cell.

(i) Epidermal Tissues :

Epidermal tissues are composed of a single layer of cells and they cover plant body. They act as a barrier between environment and internal plant tissues. In roots, they are also responsible for the absorption of water and minerals. On stem and leaves they secrete cutin (the coating of cutin is called cuticle) which prevents evaporation.

Epidermal tissues also have some specialized structure that perform specific functions; for example **root hairs** and **stomata**.

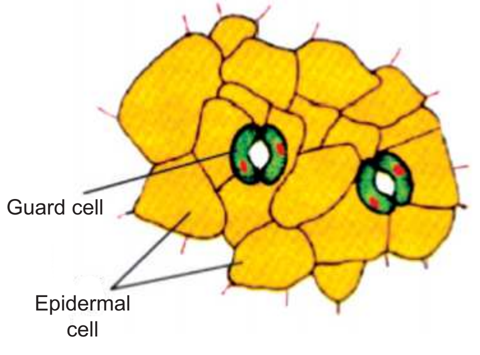


Figure 4.37 Epidermal tissue

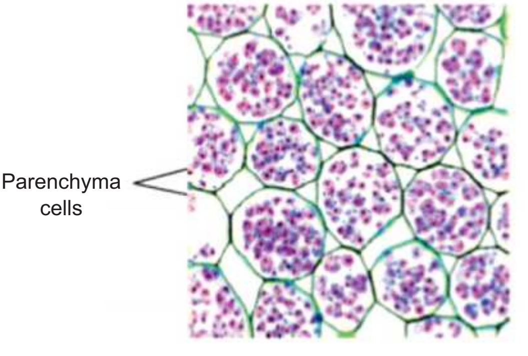


Figure 4.38 Ground tissue

(ii) Ground Tissues:

Ground tissues are simple tissues made up of **parenchyma cells**. Parenchyma cells are the most abundant cells in plants. Overall they are spherical but flat at point of contact. They have thin primary cell walls and have large vacuoles for storage of food. In leaves, they are called **mesophyll** and are the sites of photosynthesis. In other parts, they are the sites of respiration and protein synthesis.

(iii) Supporting Tissues:

These tissues provide strength and flexibility to plants. They are further of two types.

(a) Collenchyma Tissues:

They are found in cortex (beneath epidermis) of young stems and in the midribs of leaves and in petals of flowers. They are made of elongated cells with unevenly thickened primary cell walls. They are flexible and function to support the organs in which they are found.

Most parenchyma cells can develop the ability to divide and differentiate into other types of cells and they do so during the process of repairing an injury.

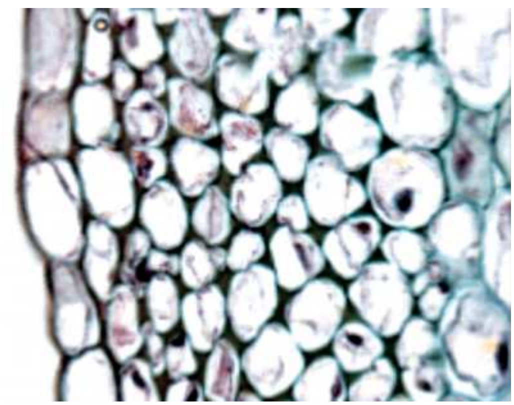


Figure 4.39 Collenchyma tissue

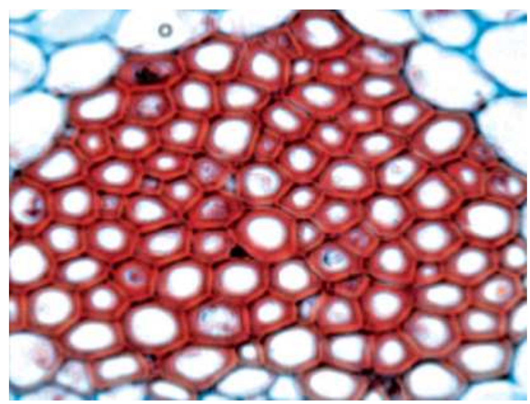


Figure 4.40 Schlerenchyma tissue

(b) Sclerenchyma Tissues :

They are composed of cells with rigid secondary cell walls. Their cell walls are hardened with lignin, which is the main chemical component of wood. Mature sclerenchyma cells cannot elongate and most of them are dead.

(B) Compound (Complex) Tissues:

A plant tissue composed of more than one type of cell is called a compound or complex tissue. Xylem and phloem tissues, found only in vascular plants, are examples of compound tissues.

(i) Xylem Tissue:

Xylem tissue is responsible for the transport of water and dissolved substances from roots to the aerial parts. Due to the presence of lignin, the secondary walls of its cells are thick and rigid. That is why xylem tissue also provides support to plant body. Two main types of cell are found in xylem tissue i.e. vessel and tracheids. **Vessels** have thick secondary cell walls. Their cells lack end walls and join together to form long tubes. **Tracheids** are made up of slender cells with overlapping ends.

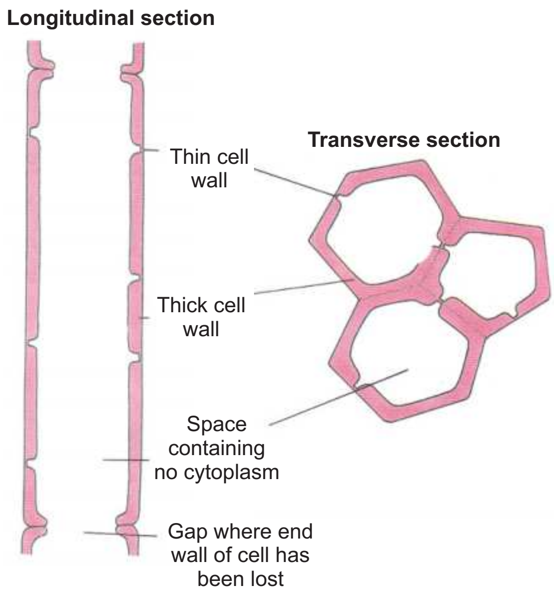


Figure 4.41 Xylem tissue

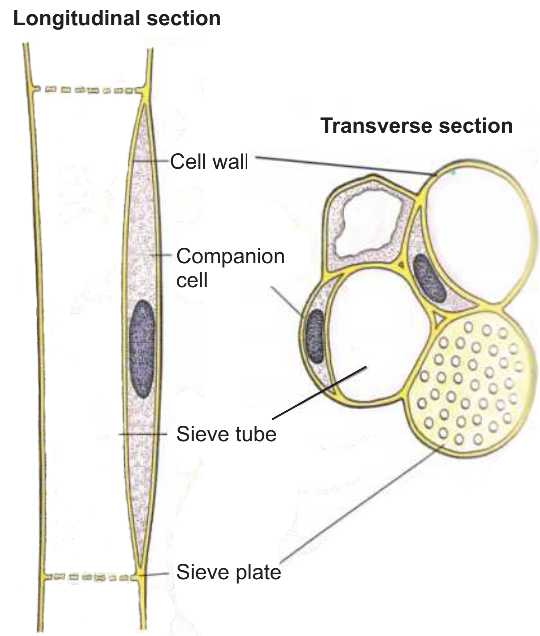


Figure 4.42 Phloem tissue

(ii) Phloem Tissue:

Phloem tissue is responsible for the conduction of dissolved organic matter (food) between different parts of plant body. Phloem tissue mainly contains sieve tube cells and companion cells. **Sieve tube cells** are long and their end walls have small pores. Many sieve tube cells join to form long sieve tubes. **Companion cells** are parenchymatous, narrow, elongated cells, and are closely associated with the sieve tube. Conduction with the sieve tube is done through the pores present on the walls of these cells. They help the sieve tubes in conduction of food materials and make proteins for sieve tube cells.

Summary

- *Zachanan Janson* is believed to be the first investigation to invent compound microscope and *Robert Hooke* improved it.
- Two parameters are important in microscopy i.e magnification and resolution.
- Another microscope is electron microscope this microscope produce higher resolution. It can be used to examine sub-cellular structures.
- A cell is the basic structural and functional unit of organisms explained by cell theory important generalization of Biology.
- There are 2 types of cells on the bases of their sub-cellular structure i.e prokaryotic and eukaryotic cell.
- The prokaryotic cell has improper nucleus i.e with out nucleus membrane while eukaryotic cell has proper nucleus surrounded by nuclear membrane.
- Cell wall is a tough, rigid, non-living, permeable outer protective layer of some cells.
- Cell- membrane is the outer most living, differentially permeable boundary of all cells.
- *S.J singer* and *G.L. Nicholson* proposed fluid mosaic model to explain the structure of cell membrane.
- Movement across cell-membrane then place through osmosis, diffusion, active transport facilitated diffusion.
- The structure present in cell called cell organelle like, Mitochondria, Golgi bodies, Endoplasmic reticulum, ribosome, lysosome, vacuoles, centrioles, plastids and nucleus.
- Cells are of variable size like bacterial cells of smallest size and egg cells of largest size.
- waste production and demand of nutrients are directly proportional to cell volume.
- Tissues are the group of similar cells may be on the basis of structure.
- In plants there are two major types of tissues i.e meristematic and permanent tissues.

Review Questions

1. Encircle the correct answer:

(i) What is responsible for the high resolution of the electron microscope?

(a) High magnification

(b) Short wavelength of the electron beam

(c) Use of heavy metals strains

(d) Very thin section

(ii) What is a function of the rough endoplasmic reticulum?

(a) Aerobic respiration (b) Intracellular digestion

(c) Synthesis of steroids (d) Synthesis of protein

(iii) Which statement about the fluid mosaic model of membrane structure is correct?

(a) The less unsaturated the fatty acid, the more fluid nature.

(b) The more unsaturated the fatty acid, the more fluid nature.

(c) Higher the temperature, less fluid nature.

(d) The lower the temperature, more fluid nature

(iv) Which process allow movement in and out of cell

I. Osmosis

II. Diffusion

III. Active transport

(a) I only (b) I and II only

(c) II and III only (d) I, II and III

(v) All are postulates of cell theory except

(a) New cell is derived from pre-existing cells.

(b) Cell does not contain the hereditary material.

(c) All living organisms are made up of one or more cells.

(d) Cell is the fundamental unit of life

(vi) Secondary wall is made up of

(a) Pectin and cellulose (b) Cellulose and protein

(c) Cellulose and lignin (d) Lignin and pectin

(vii) Select the odd one

(a) Active transport (b) Diffusion

(c) Facilitated diffusion (d) Osmosis

(viii) Trace the correct pathway of protein produce from protein factories

(a) RER → Ribosome → Golgi body → Lysosome

(b) Ribosomes → RER → Golgi body → Lysosome

(c) Golgi body → RER → Ribosome → Lysosome

(d) RER → Ribosome → Lysosome → Golgi body

(ix) Cell organelle found in animal cell and help intracellular digestion

(a) Lysosome (b) Ribosomes

(c) Mitochondria (d) Golgi apparatus

(x) Select the mismatched

(a) Plastids → Storage of chemicals

(b) Centriole → Help in cell division

(c) Ribosomes → Synthesis of steroids

(d) Mitochondria → Synthesis of ATP

2. Fill in the blanks:

(i) Microscopes are instrument designed to produce ________ visual image.

(ii) Resolution of a microscope is defined as the smallest distance between_______ points.

(iii) Magnification of a light microscope is formed by using mixture of the power of the eyepiece and the _______ lens.

(iv) Electron has a much shorter wavelength than visible light, and this allows electron microscopes to produce ___________ images.

(v) In plants, the cell wall is composed mainly of strong fibers of ___________.

(vi) Cell membrane is composed of ________ layer.

(vii) Diffusion is a _______ process, which does not require energy input.

(viii) Plant cell loses water and cytoplasm shrinks in a process called ___________.

(ix) Special type of movement of specific substances through carrier protein is ___________.

(x) The microtubules arranged in a very particular pattern to form centriole are _________ in number.

3. Define the following terms:

(i) Exocytosis (ii) Vesicles (iii) Cartilage

(iv) Nucleoplasm (v) Cyclosis (vi) Plasmolysis

(vii) Resolution (viii) Tissue (ix) Magnification

(x) Cisternae

4. Distinguish between the following in tabulated form:

(i) Prokaryotic cell and eukaryotic cell

(ii) Mitochondria and Chloroplast

(iii) Lysosome and Ribosomes

5. Write short answers of following questions:

(i) Why mitochondria is also called power house of cell?

(ii) Why iodine used to stain the onion peel?

(iii) How electron microscope is different from simple compound microscope?

(iv) Why cell membrane is semipermeable in nature?

(v) How facilitated diffusion is different from active transport?

(vi) Why cell is considered as the structural and functional unit of living things?

6. Write detailed answers of the following questions:

(i) Describe structure and function of nucleus with the help of diagram.

(ii) What is microscope? Describe types of microscopes.

(iii) Describe fluid mosaic model of cell membrane also draw the diagram.

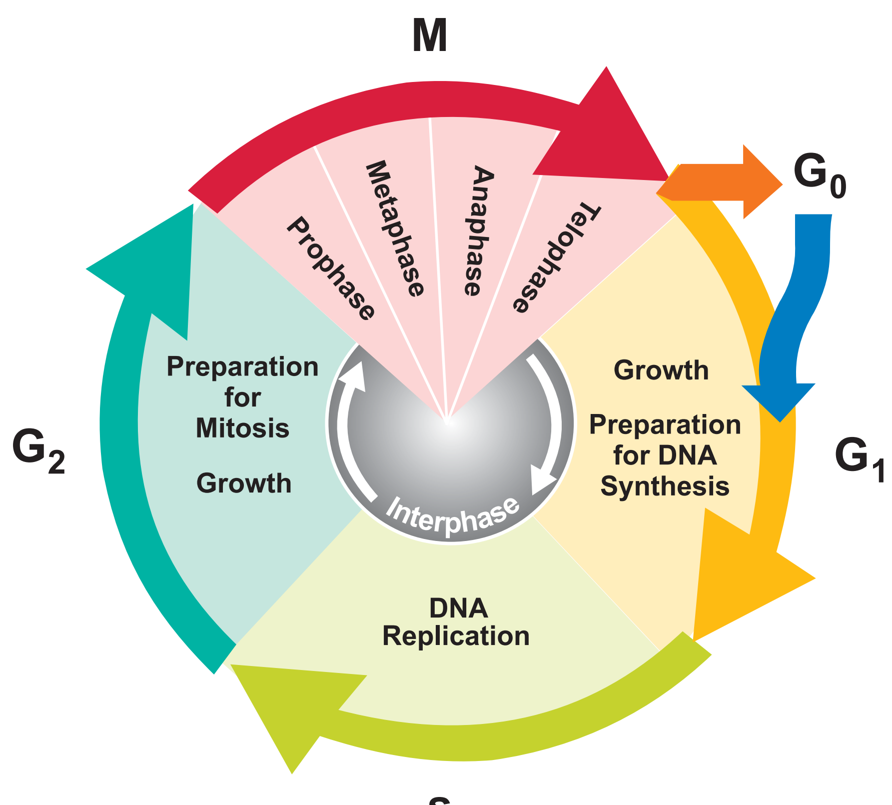
Chapter 5

CELL CYCLE

Major Concept

In this Unit you will learn:

- Chromosomes Structure and Functions
- Cell Cycle (Interphase and Division)
- Mitosis
  - Phases of Mitosis
  - Significance of Mitosis
- Necrosis and Apoptosis
- Meiosis
  - Phases of Meiosis



5.1 CHROMOSOMES

The term Chromosomes is given by German embryologist *Walter Fleming* in 1882 when he was examining the rapidly dividing cells of salamander larvae after treating with Perkin's Aniline. He observed that chromosomes colour is much darker than the rest of organelles. The term chromosomes is misnomer because its means coloured body later it was found that chromosomes are colourless bodies



Fig: 5.1 structure of chromosome

Chromosomes are thread like structure appear at the time of cell division includes found in specific numbers, made up of chromatin material in eukaryotic cell. They contain heredity units called **Genes**.

Chromosomes are made up of DNA and basic protein, Histones, appear during the cell division in the shape of rod. It has two parts arms and centromere.

The chromosomes are of different types, depending upon position of centromere. These types are:

(i) **Metacentric:** Chromosomes with equal arms.

(ii) **Sub-meta centric:** Chromosomes with un equal arms

(iii) **Acrocentric or sub-telocentric:** Rod like chromosomes with one arm very small and other very long. The centromere is subterminal.

(iv) **Telocentric:** Location of centromere at the end of chromosomes.

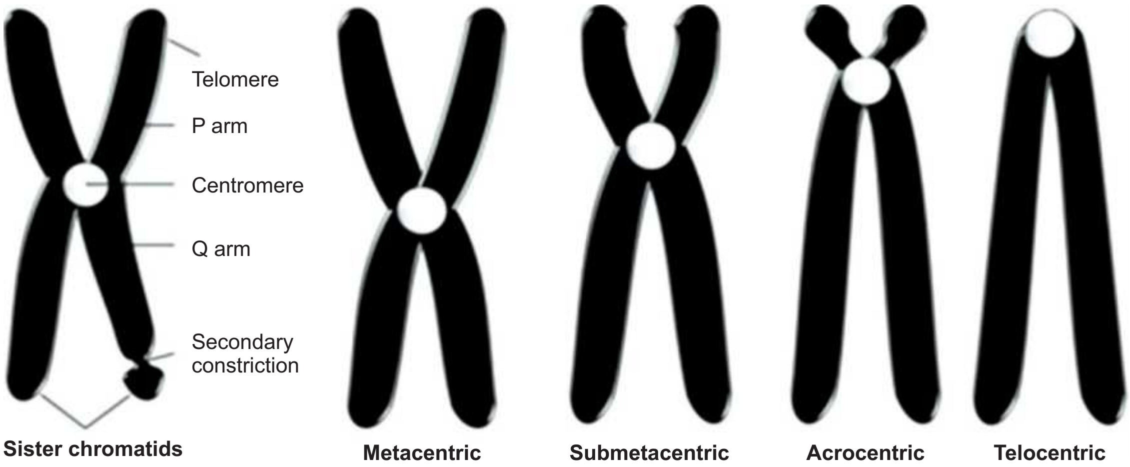


Fig: 5.2 Types of chromosomes

In the beginning of cell-division each chromosome is consist of two genetically identical copies of thread attach with each other called chromatids or sister chromatids.

Formation of chromosome:

Each chromosomes in eukaryotes are composed of chromatin fiber, which is made of nucleosomes. Chromatin fibers are packaged by proteins into a condensed structure called chromatin.

Chromatin allows the very long DNA molecules to fit into the cell nucleus. During cell division chromatin condenses further to form microscopically visible chromosomes. The structure of chromosomes varies through the cell cycle.

During cell cycle chromatin material replicate, divide and passed successfully to their daughter cells for survival of their progeny. Some time cell-division is also responsible for genetic diversity.

5.2 CELL CYCLE

The sequence of changes which occurs between one cell division and the next is called Cell Cycle.” It has two phases, **Interphase**, which is the period of non-division and **M-phase**, which is a period of cell division.

The cell cycle undergoes a sequence of changes, which involve period of growth, replication of DNA followed by cell division. This sequence of changes is called **cell cycle**.

Interphase:

The period of cell cycle between two consecutive divisions is called Interphase. It is a period of growth and synthesis of DNA. During this period the cell prepares itself for the M- phase.

The Interphase is divided further into three sub-phase, G_1- phase, S-phase and G_2-phase.

G_1-(Gap one) phase: It is the period of extensive metabolic activity, in which:

Cell grows in size, specific enzymes are synthesized and DNA base units are accumulated for the DNA synthesis.

At a point in G_1, the cell may enter into a phase called G_0 (G-knot) where cell cycle stop. It remains for days, weeks or in some cases even for the life time of the organism.

S-(Synthesis) phase: During this phase, replication of DNA occurs. As a result of it chromatin material is duplicated.

G_2– (Gap two) phase: (Pre-Mitotic Phase): The following changes occur during this phase: Cell grows in size, cell organelles are replicate in numbers as well as enzyme require for cell-division also synthesized during this phase.

5.3 MITOSIS

In this type of cell division a parent cell divides into two daughter cells in a way that the number of chromosomes in the daughter cells remains the same as in the parent cell.

Although mitosis is a continuous process, but for the study point of view we can divide it into two phases; (a) Karyokinesis - nuclear division (b) Cytokinesis - cytoplasmic division.

(a) The karyokinesis can be divided further for convenience into four phases which are **Prophase**, **Metaphase**, **Anaphase** and **Telophase**. Let us study mitosis in an animal cell.

(i) Prophase:

During early prophase chromatin material condenses and become visible as thick coiled, thread like structures called **chromosomes**. Each chromosome at this stage is already double, consists of two **chromatids**. The chromatids are attached to each other at **centromere**. The nuclear membrane gradually disappears and at the same time centrosome divides to form two centrioles, each moves towards the opposite pole of the animal cell and forms the spindle fibres. The centrioles are absent in plant cells.

(ii) Metaphase:

During this phase each chromosome arranges itself on the equator of the spindle. Each chromosome is attached to separate spindle fibre by its centromere.

(iii) Anaphase:

In this phase the spindle fibre contract, centromere of a chromosome divides and the chromatides of each chromosome separates from each other and begin to move towards the other poles. In this way one set of the chromatids (each chromatid is now an independent chromosome) move towards one pole while the other set towards the other pole.

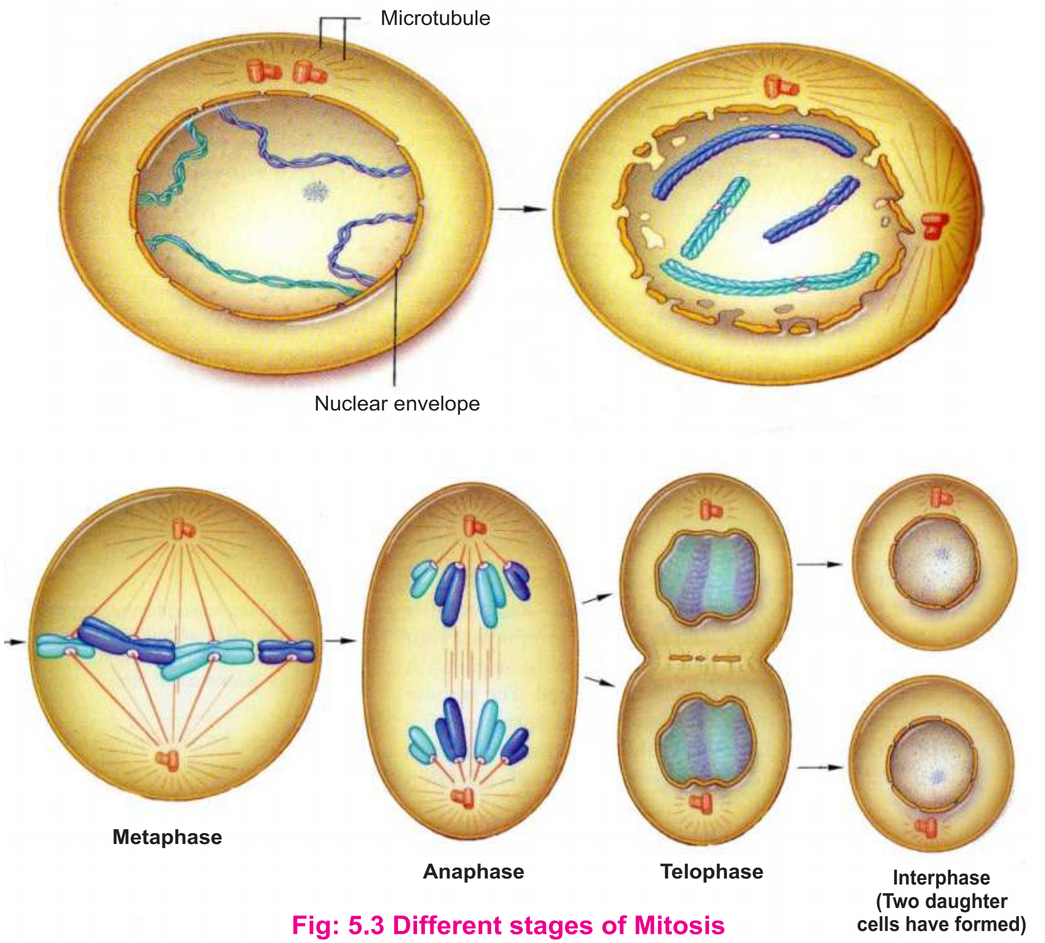


Fig: 5.3 Different stages of Mitosis

(iv) Telophase:

This is a stage when the chromatids (now called chromosomes) reach at the respective poles and their movement ceases. Each pole receives the same number of chromosomes as were present in the parent cell. The nuclear membrane is reformed around each set of chromosomes. In this way two daughter nuclei formed in each cell.

(b) Cytokinesis; soon the cytoplasm of the cell also divides and two daughter cells are formed. In animal cell cytokinesis takes place by developing a constriction. This constriction become deep to divide cytoplasm in two equal halves and two daughter cells are formed. In plant cells it occurs by developing cell plate. In this way the daughter cells become the exact copies of their parent cell.

Significance of mitosis:

Mitosis plays an important role in the life of an organism. It is responsible for development and growth of organisms by increasing exact copies of cells. With few exception all kinds of asexual reproduction and vegetative propagation take place by mitosis. The production of new somatic cells, such as blood cells depends on mitosis. The healing of wounds, repair of wear and tear within organism is also dependent upon the mitotic division.

5.4 APOPTOSIS AND NECROSIS (two ways of cell death)

Cell in an organism depends upon various extra cellular signals for its regulated and controlled activities. It means all the activities even the death of cells is programmed.

Is cell death beneficial?

Programmed cell death helps in proper control of multicellular development, which may lead to deletion of entire structure, e.g. the tail of developing human embryo, or some part an organ which is more required like tissue between developing digits.

Two ways of cell death in Multicellular organisms:

Apoptosis or Self - Destruction (Autophagy): "Programed change which lead to sequence of physiological changes in cell by which cells commit suicide collectively called **Apoptosis**".

Necrosis:

This type of cell death which is caused by external factors i.e infection, toxin and tumor i.e accidental cell death.

5.5 MEIOSIS (Reduction Division)

Meiosis is a type of cell division in which single cell divides into four daughter cells and number of chromosomes becomes half in each daughter cell.

In animal meiosis takes place in germ cell to produce gametes i.e. Sperms and Eggs whereas in plants it takes place in spore mother cells (S.M.C) to produce spores.

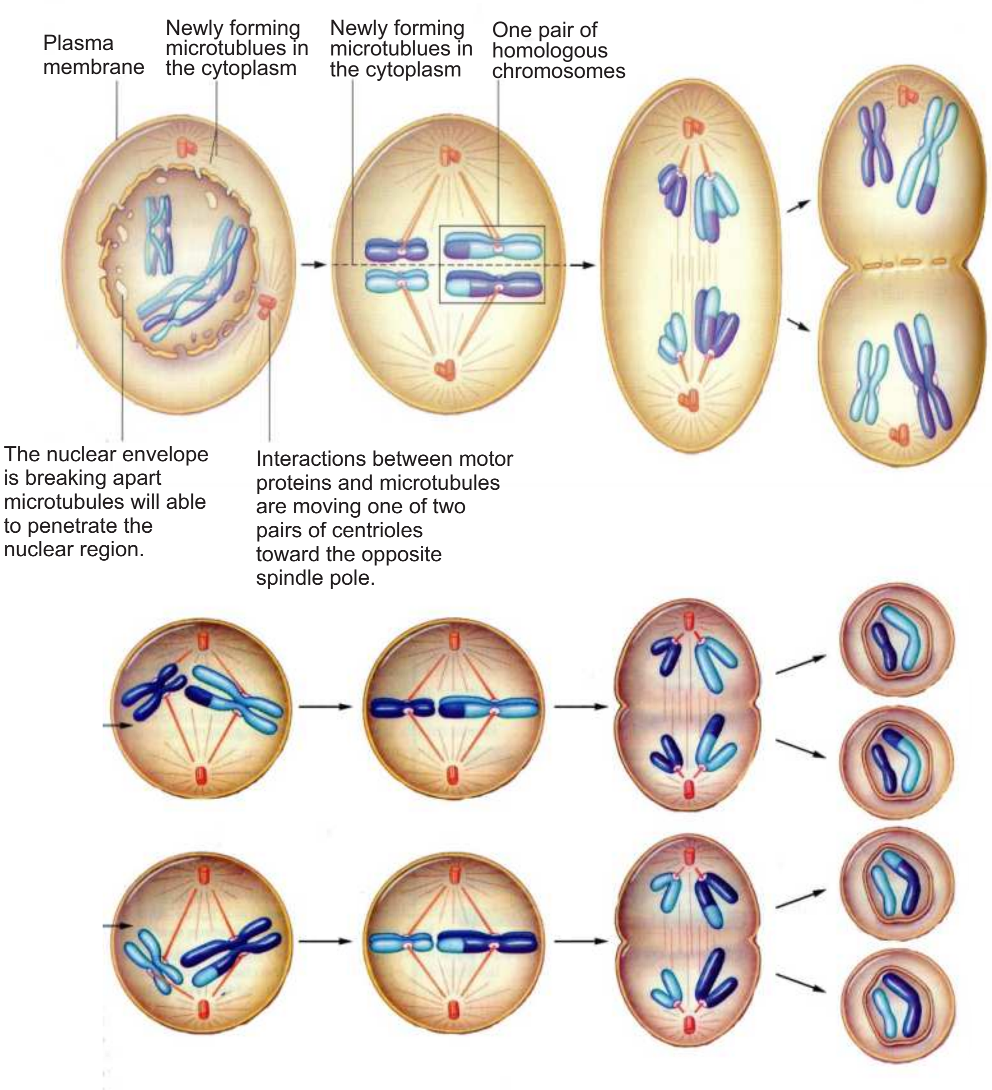


Fig: 5.4 Different stages of Meiosis

Events of Meiosis:

Meiosis is a series of two divisions, MEIOSIS I and MEIOSIS II which result in the formation of four haploid cells.

Meiosis I (First Meiotic Division)

First meiotic division is the reduction division during which the chromosomes number is reduced to half. Meiosis I consists of Prophase I, Metaphase I, Anaphase I and Telophase I.

Prophase I:

It consists of the longest phase of meiosis. It can be subdivided into following sub stages:

(1) Leptotene (2) Zygotene (3) Pachytene

(4) Diplotene (5) Diakinesis

(1) Leptotene:

During this sub stage following changes occur; The chromatin network break into specific number of long thin beaded thread called leptotene. Each thread has two morphologically similar leptene in each cell called homologous structure.

(2) Zygotene:

During this sub stage the Homologous (Similar structure) chromosomes, which comes from the mother (by ovum) and father (by sperm) are attracted towards each other and their lengthwise pairing takes place. The pairing of homologous chromosomes is known as **synapsis**, while the paired homologous chromosomes are known as **bivalent**.

(3) Pachytene:

The synaptic forces of attraction between each bivalent decrease and the chromosomes uncoil and separate. The separation is however incomplete and paired chromosomes are in contact with each other at one or more points, called Chiasmata. Each homologous chromosome split longitudinally except in the centromere region. Now each bivalent is composed of four chromatids and therefore is known as **bivalent tetrad**.

(4) Diplotene:

The homologous chromosomes exchange their parts of chromatid at Chiasmata. This exchange of segments of chromatids at chiasmata between the homologous chromosomes is called Crossing Over.

(5) Diakinesis:

During this sub stage; nucleoli and nuclear membrane are disappeared, whereas Mitotic Apparatus (spindle) is completed. Chiasmata moves from the centromere towards the ends of the chromosomes like a zipper.

This type of movement of chiasmata is known as Terminalization. At the end of Diakinesis chromatids still remain compacted at their ends.

Metaphase I:

Following changes occur in this phase:

The bivalent line up at the equatorial plane. The centromere of each chromosome attaches with same fibres of spindle.

Anaphase I:

At this stage one chromosome from each member of homologous pair (bivalent) begins to separate and move towards its respective pole by the contraction of spindle fibers.

The actual reduction occurs at this stage because half the number of chromosomes moves to each pole. Moreover as a result of crossing over the two chromatids of a chromosome do not resemble with each other in the genetic terms.

Telophase I:

The nuclear membrane form around the chromosomes at each pole and chromosomes become uncoil. The nucleolus reappears and thus two daughter nuclei formed.

Cytokinesis: Telophase may or may not be accompanied by cytokinesis and daughter cells formation.

Interphase: Following Telophase I (If this stage occurs), there is a short period called **Interphase** before meiosis II. It is similar to Interphase between Mitotic divisions except that DNA replication does not occur. Replication of DNA is unnecessary because each chromosome already has two chromatids.

Second Meiotic Division (Meiosis II):

The second meiotic division is actually the mitotic division which divides each haploid cell formed during meiosis I into two daughter haploid cells. The second meiotic division includes:

(1) Prophase II (2) Metaphase II (3) Anaphase II (4) Telophase II

(1) Prophase II:

The spindle fibres are formed. The nuclear membrane and the nucleolus disappear.

(2) Metaphase II:

The chromosomes are attached to half spindle fibers by their centromere and get arranged at equatorial plane. Each chromosome attach with separate fiber of spindel.

(3) Anaphase II:

The spindle fibers attached to the centromeres shorten and the chromatids of chromosomes are pulled away from one another. This movement continues until one complete set of chromosomes is positioned at each pole of the cell.

(4) Telophase II:

The spindle fibers disappear completely and chromosomes begin to uncoil. They become longer and indistinct and form group at each pole. Around each group nuclear envelope is formed.

After the kayrokinesis in each haploid meiotic cell the cytokinesis i.e. division of cytoplasm occurs and thus four haploid cells are formed.

What happens in absence of meiosis?
In the absence of meiosis number of chromosomes would have been doubled giving rise to abnormal growth, changes in species characteristics and or may prove fatal.

Significance of Meiosis:

(1) Constant number of chromosomes:

Meiosis maintains chromosome number constant from generation to generation. It is due to the fact that meiosis reduces the diploid number of chromosomes to half i.e. haploid in the gametes.

During fertilization the diploid number of the chromosomes is restored.

(2) Responsible for genetic variation among species:

By crossing over, the meiosis provides an opportunity for the exchange of the genes between homologous chromosome and thus cause the genetic variations among the species. The variations are the raw material of the evolutionary process.

Meiotic errors:

In normal course of meiosis, the two chromosomes of each homologous pair separates and enter into two gametes, but sometimes a pair of homologous chromosomes fails to separate from one another, during meiosis I. this phenomenon is called Non-disjunction.

Non-disjunction produce gametes with abnormal number of chromosome i.e either with less or extra chromosome. If such abnormal gametes fuse with normal gametes, the resulting zygote will also have abnormal number of chromosome.

Summary

- Term chromosome is given by *Fleming* in 1882. These are thread like structures appear at the time of cell- division made up of chromatin material in specific number in Eukaryotic cell.
- Chromosomes are made up of DNA and histone protein.
- There are four types of Chromosome i.e Metacentric, Sub-metacentric Aerocentric and Telocentric.
- Sequences of change occur between two successive Cell division called cell-cycle.
- Cell-cycle is mainly consist of two phases i.e cell-division and inter phase.
- Inter phase is divided further into three sub phases G1, S and G2 phases.
- Mitosis is the type of cell division, where a parent cell divides into two daughter cells, with same number of chromosomes as the parent cell contain.
- Meiosis is the type of cell division in which a single cell divides into four daughter cells and number of chromosomes become half of the parent cell.
- In animal meiosis takes place in the Germ cells while in plant it takes spore mother cells to produce gametes and spores respectively.
- Meiotic error, where a pair of homologous Chromosomes fails to separate form one another called non disjunction. This non disjunction produce gametes with abnormal number of chromosomes with less or extra chromosomes.

- Cell-death occur in two ways:
  - (i) Apoptosis; programmed cell death, which help in proper control of development.
  - (ii) Necrosis; cell death occur by external factor or accidental cell-death.

Review Questions

1. Encircle the correct answer:

(i) Which processes involve mitosis?

(a) Growth, reduction division and asexual reproduction.

(b) Growth, repair and asexual reproduction.

(c) Growth, repair and semiconservative replication.

(d) Growth, reduction division and repair

(ii) What occurs in metaphase of mitosis?

(a) Chromosome line up on the equator of the cell.

(b) Chromatids reach the poles of the spindle.

(c) Chromatids separate and move to opposite poles

(d) Chromosomes start to coil up and become visible.

(iii) Select the mismatched

(a) Anaphase → Chromatids move

(b) Prophase → Centriole move

(c) Telophase → Nuclear membrane disappear

(d) Metaphase → Chromosome line up.

(iv) Which process occurs during prophase of mitosis in an animal cell?

(a) Division of centromeres (b) Formation of chromosomes

(c) Replication of DNA (d) Separation of centrioles

(v) Sequence of physiological changes by which cell commit suicide.

(a) Apoptosis (b) Necrosis

(c) Autophagy (d) Both “a” and “b”

(vi) Choose the incorrect statement regarding meiosis.

(a) Maintain chromosome number from generation to generation.

(b) Reduces the diploid number of chromosomes to half

(c) Takes place in germ cell to produce gametes

(d) Production of new somatic cells from germ cells.

(vii) A type of cell division in which spore mother cell produce spores.

(a) Amitosis (b) Mitosis

(c) Meiosis (d) Both “a” and “c”

(viii) Stage of mitosis in which chromatids reach the poles and their movement ceases.

(a) Prophase (b) Metaphase

(c) Anaphase (d) Telophase

(ix) Stage of meiosis in which centromeres shorten and the paired chromatids are pulled away from one another.

(a) Anaphase-II (b) Metaphase-II

(c) Telophase-II (d) Prophase-II

(x) Phenomenon in which pair of homologous chromosome fails to separate called.

(a) Non-disjunction (b) Terminalization

(c) Synapsis (d) Linkage

2. Fill in the blanks:

(i) Chromosomes are thread like structures appear at the time of____________.

(ii) Sequence of changes which occurs between one cell division and the next is called________.

(iii) The two chromatids are attached to each other at________.

(iv) Chromosomes in the cell which are similar to each other in shape and size are called_________.

(v) Chromosomes with one arm very small and other very long called__________.

(vi) Chromosomes consist of two genetically identical copies of thread called_______.

(vii) Period of extensive metabolic activity, in which cell grow, enzymes are synthesizes______.

(viii) In animal meiosis produces______________.

(ix) During metaphase homologous chromosomes arrange themselves on the _______.

(x) Cell death which is caused by external factor called________.

3. Define the following terms:

(i) Pachytene (ii) Cytokinesis (iii) Bivalent

(iv) Chaismata (v) Chromatids (vi) Diakinesis

(vii) Terminalization (viii) Necrosis (ix) Crossing over

(x) Centromere

4. Distinguish between the following in tabulated form:

(i) Prophase and Prophase-I (ii) Prophase and Telophase

(iii) Apoptosis and Necrosis

5. Write short answers of following questions:

(i) Why meiosis-I is called reduction division?

(ii) Why mitosis is necessary for growth?

(iii) How number of chromosomes remains constant from generation to generation?

(iv) Why interphase is called as phase of high metabolic activities?

(v) Why interphase between meiosis-I and meiosis-II is short?

6. Write detailed answers of the following questions:

(i) Describe various stages of mitosis with suitable diagrams.

(ii) Describe stages of meiosis-I with suitable diagrams.

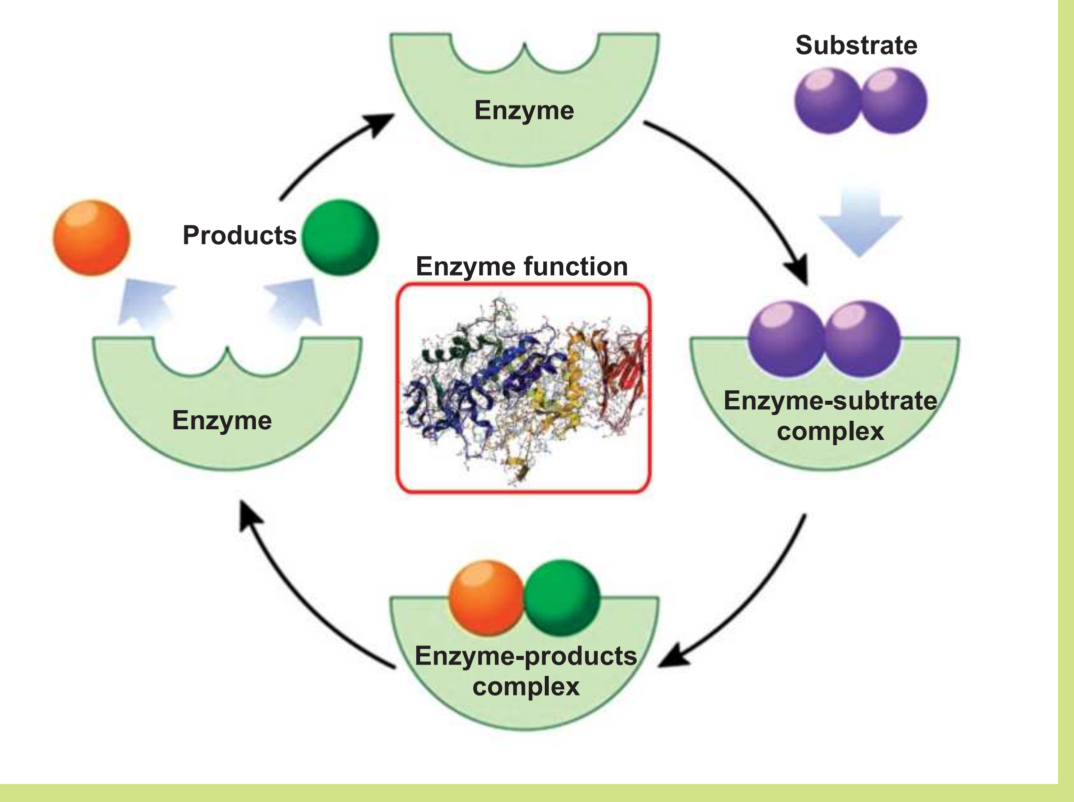
ENZYMES

Chapter 6

Major Concept

In this Unit you will learn:

- Definition and Characteristics of Enzymes
- Mechanism of Enzyme Action (Lock-n-key Model)
- Specificity of Enzyme



Life is another name of activity, therefore thousands of chemical reactions take place in the body of an organism. These reactions of an organism are collectively called metabolic reactions and this phenomenon of chemical activity called metabolism. The metabolic activities are always of two types, either constructive or destructive.

In constructive reactions large molecules are formed to form a structure of cell or body. These reactions are called anabolic reactions and this type of metabolism is called **anabolism**. On the contrary, the destructive reaction in which large molecules breakdown in small molecules to produce energy or to re-utilize further or to discard called catabolic reactions. The type of this metabolic activity is called **catabolism**.

The chemical reaction requires particular conditions to carry down at proper rate, especially temperature and pressure. The conditions of temperature and pressure inside cell or organism are generally found not suitable for chemical reactions e.g. inside human body normal temperature remain $37^{\circ}C$ and pressure is 120/80 m.m of Hg. These conditions of temperature and pressure are not enough to perform any chemical reactions. Now question arises here how biochemical or metabolic reactions can occur without altering these conditions?

Now body requires some facilitators. These facilitators helps to perform biochemical reactions at low energy. From above discussion it is clear now that each reaction requires some amount of minimum energy to initiate a reaction. This minimum amount of energy is called **activation energy**. If this amount is high the difficult will be the reaction or vice versa e.g. the activation energy needed to break a glucose molecule initially requires energy of 2 ATP molecules.

6.1 DEFINITION

The high amount of activation energy cannot be provided by organism itself therefore they require some facilitators to reduce this activation energy. These facilitators are special molecules made up of mostly protein called **enzymes** (En=inside, zyme = yeast). The name was coined due to observation when yeast was introduced in fruit sap which converted it into alcohol. Now the enzyme are defined as the biocatalyst which facilitate chemical reaction by lowering activation energy.

This action of enzyme allows biological reaction to proceed rapidly at relatively low temperature and pressure tolerable by living organism.

6.2 CHARACTERISTICS OF ENZYMES

- Enzymes are biocatalyst, made up of mostly proteins and therefore three dimensionally folded chains of amino acids with a specific shape. This shape is determined by the sequence of amino acids held together by bonds, for example Hydrogen bonds. Enzymes speed up reactions by bringing reactants together and reducing the activation energy required to start the reaction (enzymatic reaction)
- When an enzyme starts a chemical reaction, catalyzes the reaction hence does not utilized itself which means even a single or little amount of enzyme can start a reaction and catalyze fastly.
- Their presence does not affect the nature or properties of end products.
- Reactants of enzyme are called substrate.
- They are very specific in their action; a single enzyme catalyzes only a single chemical reaction or a group of related reactions.
- A small portion of enzyme where substrate attaches with enzyme is called **active site**. The shape of active site is complementary to shape of the substrate.
- They are sensitive to even a minor change in pH, temperature and substrate concentration.
- Some enzymes require cofactor for their functioning; a cofactor is a non-protien substance which may be organic or inorganic. Zn^{+2}, Mg^{+2}, Mn^{+2}, Fe^{+2}, Cu^{+2}, K^{+1} and Na^{+1} the organic cofactors are NADP, NAD and FAD are used in enzymes as cofactors.

> Cofactor can be categorized into prosthetic group (if organic cofactors are tightly bound to an enzyme) and Coenzymes (if organic cofactors are loosely attached with an enzyme)

- Many enzymes work in a sequential manner to produce a specific product. This pathway is called metabolic pathway.
- Activity of enzymes can be enhanced by activator and can be decreased by inhibitors.
- An **enzyme inhibitor** is a molecule that binds to an **enzyme** and decreases its activity. Since blocking an **enzyme's** activity can kill a pathogen.

6.2.1 Uses of enzymes:

Many enzymes are used commercially in industries. The most common industries are:

- **Paper industry-** To get cellulose for paper making.
- **Food industry-** For making bakery products and pizza.
- **Brewing industry-** For conversion of sugar into alcohol.
- **Bio-detergents-** Use to remove different type of stains.

6.2.2 Factors affecting the activity of an enzymes:

In nature, organisms adjust the conditions of their enzymes to produce an optimum rate of reaction, where necessary, or they may have enzymes which are adopted to function well in extreme conditions where they live.

Substrate Concentration:

It has been shown experimentally that if the amount of the enzyme is kept constant and the substrate concentration is then gradually increased, the reaction velocity will increase until it reaches a maximum after which further increase in the substrate concentration produces no significant change in the reaction rate.

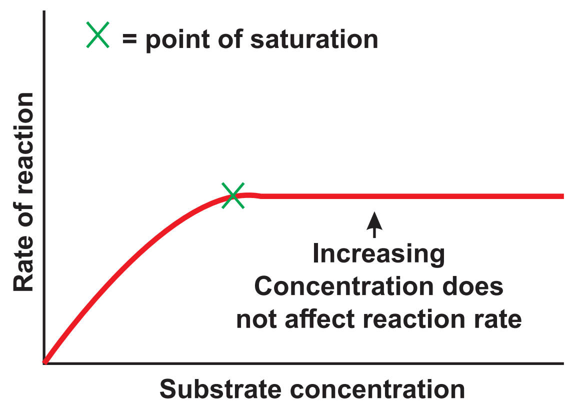


Figure 6.1 Effect of substrate concentration on enzyme activity

In other words, the enzyme molecules are saturated with substrate. The excess substrate molecules cannot react until the substrate already bound to the enzymes has reacted and been released (or been released without reacting).

Temperature:

The protien nature of the enzymes makes them extremely sensitive to thermal changes. Enzyme activity occurs within a narrow range of temperatures compared to ordinary chemical reactions. Enzymes catalyse by randomly colliding with substrate molecules, increasing temperature and increases collision which also increases the rate of reaction,

forming more product. However, increasing temperature also increases the vibrations and structure of enzymes is lost i.e denature enzyme. These changes decreases the rate of enzyme action or it may seized completely.

In summary, as temperature increases, initially the rate of reaction will increase, because of increased kinetic energy. However, the effect of bond breaking will become greater and greater, and the rate of reaction will begin to decrease as shown in given diagram.

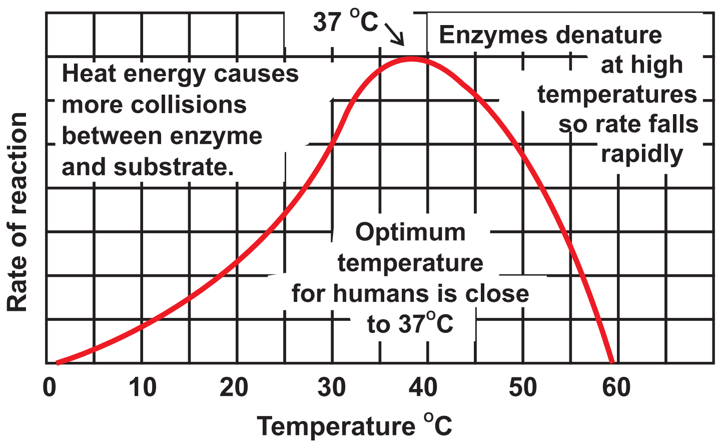


Figure 6.2 Effect of temperature on enzyme activity

pH:

Enzymes are also sensitive to pH due to their protien nature. All enzymes work at their maximum rate at narrow range of pH. The point where the enzyme is most active is known as optimum pH. For example, pepsin works at a low pH i.e. it is highly acidic, while trypsin works at a high pH i.e. it is basic. Most enzymes work at neutral pH 7.4. Small changes in pH above or below the optimum do not cause a permanent change to the enzyme, since the bonds can be reformed. However, extreme changes in pH can cause enzymes to denature and permanently lose their function.

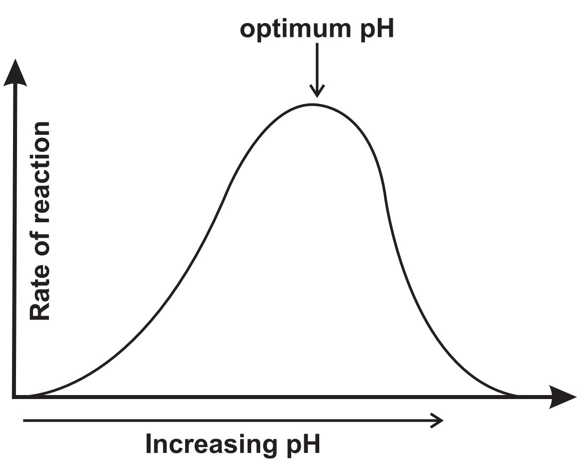


Figure 6.3 Effect of pH on enzyme activity

6.3 MECHANISM OF ENZYME ACTION

Enzyme catalyzes the reaction by attaching to substrate which ends to the product formation. Enzyme exposes its active site to attract specific substrate, makes **enzyme substrate complex** (ESC) after which the product is formed and enzyme is detached from it and used again for the same reaction.

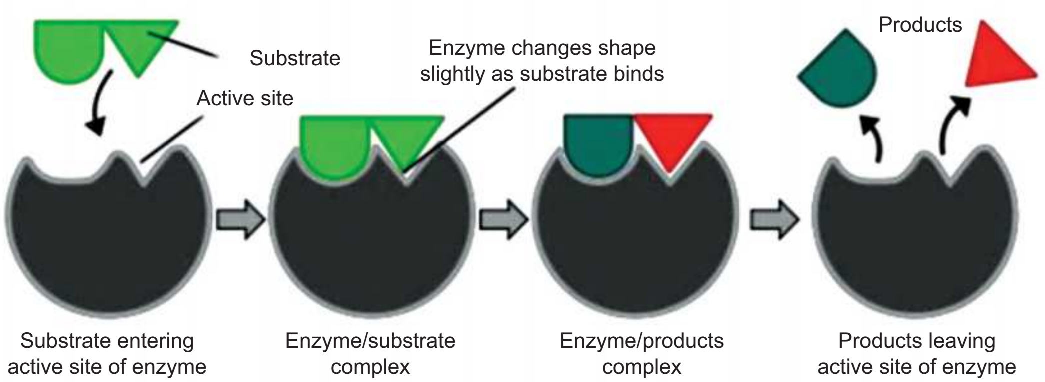


Figure 6.4 Mechanism of enzyme action

6.3.1 Action of Enzyme:

In order to understand the mechanism of enzyme action two theories are proposed; Lock and key model and Induced fit model.

1. The lock and key model:

This theory was first postulated by Emil Fischer in1894 shows the high specificity of enzymes.

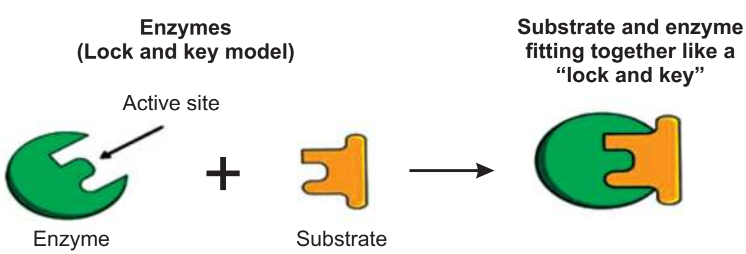


Figure 6.5 Lock and Key model

The "Lock and Key" model to demonstrate how enzymes and substrates fit together. Each enzymes fits specifically to a certain substrate. For example Lipase fits together with lipids to break them down.

This theory explains that the enzyme and the substrate possess specific complementary geometric shapes that fit exactly into one another like a key into a lock, only the correct size and shape of the substrate (the key) would fit into active site (the key hole) of the enzyme (the lock). As shown in the figure 6.5. However, it does not explain the stabilization of the transition state that the enzyme achieve.

2. Induced fit model:

The induced fit model suggested by Daniel Koshland in 1958, it explains that active site continuously changes it shape until the substrate bind to it. It also says that active site of enzyme is flexible (lock and key theory doesnot explain it).

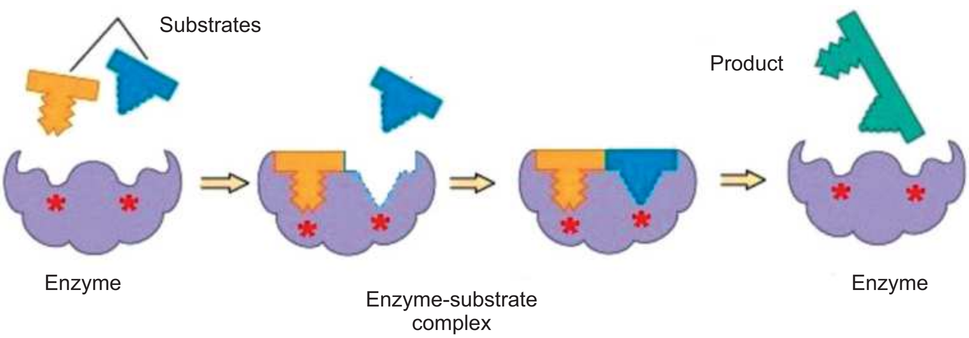


Figure: 6.6 Induced fit model

6.4 SPECIFICITY OF ENZYME

In the human body there are more than 1000 known enzymes and all work with their own substrates. As earlier we have discussed, enzymes are specific in nature therefore a particular enzyme can only bind to its specific substrate and it's all due to its active site. Active site of the enzyme possesses some geometric shape and as the enzymes are made up of protiens and protiens contain different type of amino acids which carry different charges/nature like acidic, basic, hydrophilic etc hence active site is highly specific to its substrate.

Some of the enzymes catalyzes the reaction by recognizing the bond formed between the molecules, the functional group present in the molecules or the geometric shape of the molecules.

There are TWO categories of enzymes: intracellular and extracellular. Intracellular enzymes work inside the cell such as ATPase, cytochrome C reductase etc and extracellular enzymes work outside the cells such as pepsin, lipase etc.

For example: proteases are the enzymes which catalyzes the protiens only and lipase acts on lipids only. It means the enzymes are bond specific, so lipase can act an ester bond in lipids/fats substances.

Summary

- Reactions occur in living organisms called metabolic reaction.
- There are two types of metabolic reaction occur in organisms.
- Anabolism reactions are constructive reactions.
- Catabolic reactions are destructive reactions.
- The minimum amount of energy require to activate a reaction called activation energy.
- The biochemical reaction require high amount activation energy.
- The molecules which facilitate biochemical reaction by reducing activation energy called enzymes.
- Enzymes are biocatalyst made up of mostly proteins and therefore are three dimensionally folded chains of amino acids with a specific shape.
- Reactants of enzymes are called substrate.
- Small portion of enzymes, where substrate attach called active site.
- Enzymes are sensitive to pH, temperature and substrate concentration.
- Activity of Enzymes can be Enhanced by activator and declined by inhibitors.
- Many enzymes are used commercially in industries, like paper, food, brewery, bio-detergents industries.
- The enzymes attach with Substrate form enzymes substrate complex (ESC) after completion enzyme detached while product is formed.
- There are two models to explain enzyme action.
  (i) Lock and Key model (ii) Induce fit model

Review Questions

1. Encircle the correct answer:

(i) All are characters of enzymes except.
- (a) Enzyme speed up a biochemical reaction.
- (b) Enzymes are sensitive to minor change in pH
- (c) Enzyme activity enhanced by inhibitors
- (d) Enzyme portion where substrate attach called active site

(ii) Enzymes are
- (a) Steroid in nature
- (b) Protein in nature
- (c) Lipid in nature
- (d) Carbohydrate in nature

(iii) Metabolic reactions are
- (I) Constructive reactions
- (II) Destructive reactions
- (III) Inhibiting reactions

(a) I only (b) I and II only (c) I, II and III (d) II and III only

(iv) The point where the enzyme is most active is known as
- (a) Neutral pH
- (b) Acidic pH
- (c) Basic pH
- (d) Optimum pH

(v) Active site continuously changes it shapes until the substrate do not bind to it, is statement of.
- (a) Induce fit model
- (b) Lock and key model
- (c) Fluid mosaic model
- (d) Both “a” and “b”

(vi) Select the mismatched
- (a) Proteases → Carbohydrate
- (b) Lipases → Lipids
- (c) Trypsin → Protein
- (d) All are correctly matched

(vii) Chemical reaction requires particular conditions to carry down at proper rate, especially.
- (a) Temperature and Nature
- (b) Nature and Pressure
- (c) Nature and Structure
- (d) Temperature and Pressure

(viii) All are factors affecting enzyme activity except.

(a) pH (b) Substrate concentration
(c) Organic solvent (d) Temperature

(ix) Rate of reaction will increase when temperature

(a) Increases (b) Decreases
(c) Below 10°C (d) Both "a" and "c"

(x) Choose the correct statement regarding lock and key model.

(a) Enzyme and substrate posses' specific complementary geometric shapes.
(b) Active site of enzyme is flexible
(c) Active site continuously changes
(d) All above statements are correct.

2. Fill in the blanks:

(i) There are ______________ types of metabolic reactions.

(ii) Enzymes catalyze chemical reaction by ______________ the activation energy.

(iii) Presence of enzyme does not affect the nature or properties of ______________.

(iv) In constructive reaction ______________ molecules are formed.

(v) Activity of enzymes can be enhanced by ______________.

(vi) Small portion of enzyme where substrate attach with enzyme called ______________.

(vii) Enzyme activity decreased by ______________.

(viii) As temperature increases, initially the rate of reaction will ______________.

(ix) Extreme changes in pH can cause enzymes to ______________.

(x) In the human body there are more than __________ known enzymes.

3. Define the following terms:

(i) Substrate (ii) Active site (iii) Inhibitor
(iv) Activator (v) Anabolism (vi) Catabolism
(vii) Activation energy (viii) Cofactor (ix) Prosthetic group
(x) Coenzymes

4. Distinguish between the following in tabulated form:

(i) Activator and Inhibitor

(ii) Anabolism and Catabolism

5. Write short answers of following questions:

(i) Why enzymes are specific in nature?

(ii) How enzyme reduces the amount of activation energy?

(iii) Why presence of enzymes does not effect on the nature and properties of end product?

(iv) How substrate concentrations affect enzyme activity?

(v) How enzymes are uses in industries?

6. Write detailed answers of the following questions:

(i) What are enzymes? Describes characteristics of enzymes.

(ii) Describe factors affecting enzyme activity.

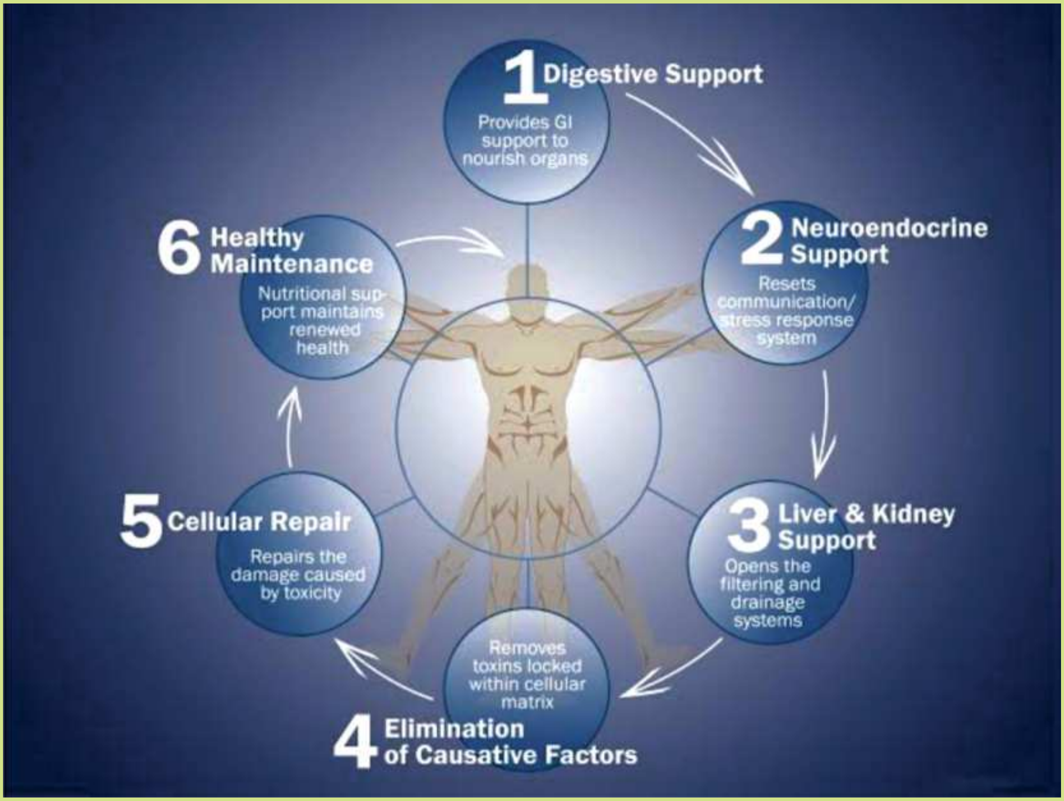
BIOENERGETICS

Chapter 7

Major Concept

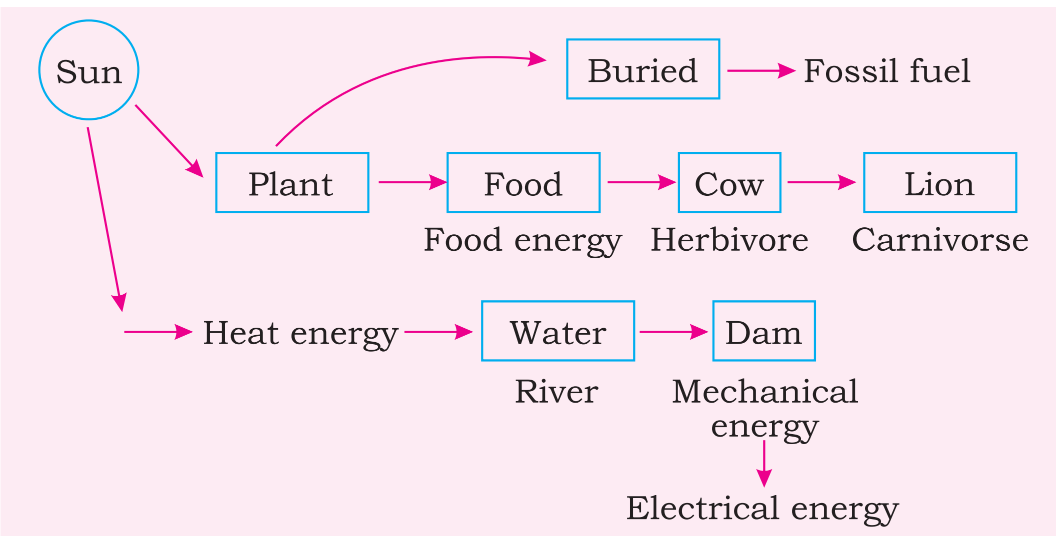
In this Unit you will learn:

- **Introduction and Role of ATP**
- **Photosynthesis**
  - Introduction of Equation
  - Role of Chlorophyll and Light
  - Limiting Factors in Photosynthesis
- **Respiration**
  - Aerobic Respiration, Anaerobic Respiration
  - Mechanism of Respiration (Glycolysis, Krebs Cycle, Electron Transport Chain)



Every machine requires energy (Capacity to do work) for performing its functions, like automobiles which require fuel to produce energy. Cell phones have batteries which store energy and utilize it for their working. Living Organisms are also like machine which require nutrients in the form of food. The special molecules of food contain energy. Here question arises, from where this energy comes in fuel and food molecules?

The only source of energy on earth is Sun. Energy of the Sun reaches earth in the form of light (light energy). This light energy is converted into chemical energy by living organisms or in heat energy stored by non-living things.



The above chart shows that conversion of energy from one form to another form explained by law of conservation of energy or first law of thermodynamics which states that energy can neither be created nor be destroyed but it can change from one form to another form.

As we can see that the heat energy of light converts in K.E. energy which flows water. This K.E. of water in dams is converted into mechanical energy when falls on turbine. This mechanical energy converts into light energy in bulbs and LED lights or again in mechanical energy in our fans.

On the other hands this light energy when falls on green parts of plant is captured and converted into chemical energy. This chemical energy is stored as food energy in plants. When these parts of plant are eaten by

animal this energy transferred into them, where the organisms buried and remain under pressure inside earth crust for millions of year their chemical energy is converted into fossil fuel.

7.1 BIOENERGETIC AND ROLE OF ATP

The study of this conversion of free energy into different forms by living organisms is called **Bioenergetics**. It is the part of biology, Physics and chemistry concerned with the energy involved in making and breaking of chemical bonds found in the molecules of organisms. Bioenergetics can also be defined as the study of energy relationships, energy transformation and transmission in living organisms.

7.1.1 Chemical Process of Energy Transmission:

In living organisms the energy is transferred through gain or loss of electrons during formation and breaking of chemical bonds. There are two chemical processes where it occurs, known with the name of oxidation and reduction. The oxidation reactions are those reactions in which loss of electron (e-) and proton occurs. These electrons carry energy from the molecules from where they release to the molecules where they added e.g. iron reacts with oxygen to form a chemical called rust, in this reaction iron (Fe) loses some e- which transfer to oxygen. In this reaction Fe is oxidized and it transfers its energy to oxygen through electrons. On the other hand, reaction occur called reduction, where gain of e- and H+ occur. This gain of e- also brings energy which is stored in it.

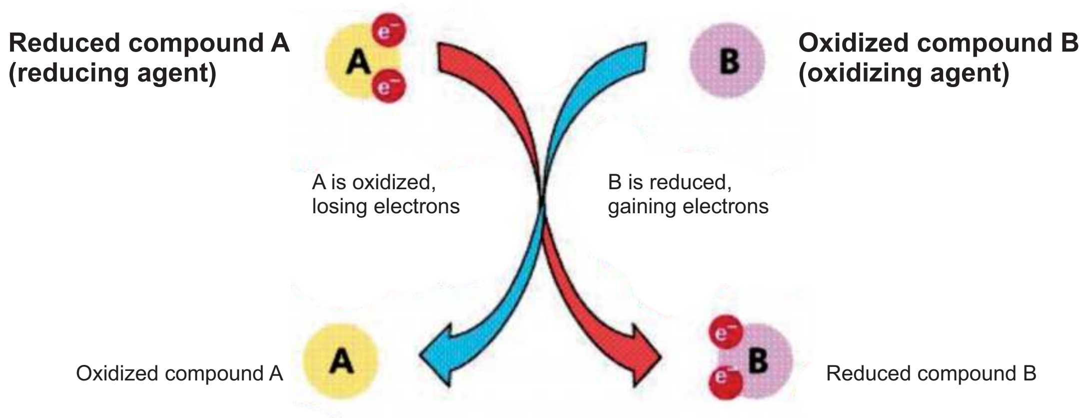
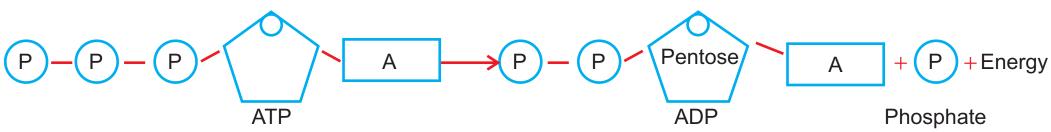


Fig:7.1 Diagram showing oxidation and reduction process

In living organisms these oxidation - reduction (Redox) reactions occur continuously to transfer energy from one molecule to other molecule, without these reactions energy transfer becomes impossible in living system.

7.1.2 Energy Currency in living organism:

In our home we store energy in batteries when electricity is available from usual source or when light energy is available we capture it by solar plates. This energy of battery then is utilized at the time of power shutdown (load shedding). Living organisms also have similar type of system to store energy. This energy is stored in a special molecule called Adenosine Tri-Phosphate (ATP). In organisms, energy is liberated during any oxidation reaction, this energy is utilized by molecules called Adenosine Di-Phosphate (ADP) to form a bond with phosphate (P). As a result the ADP become ATP, energy of oxidation is now stored in ATP.



The amount of energy stored is 7.3 Kcal / mole, this stored energy in ATP will be utilized by living organism for performing any type of work e.g. transport of molecules against the concentration gradient. The energy is now become free (liberated) by breaking ATP molecule.

$$ATP \longrightarrow ADP + P + Energy\ (7.3\ K\ Cal\ /\ mole)$$

So the formation of ATP is endergonic (energy intake) process and breakdown of ATP is exergonic (energy liberating) process.

7.2 PHOTOSYNTHESIS

Photosynthesis is the fundamental process in which basic organic molecules and O_2 are produced for all bio-molecules and living organisms. This process in carried out by chlorophyll containing organisms like plants, algae, some protozons and some bacteria. Word **photo** means **light** and **synthesis** means **to prepare**. Plants utilize simple inorganic molecules carbon dioxide (CO_2) and water (H_2O) which react by using light energy in the presence of pigments like Chlorophyll to form glucose and oxygen.

Equation:

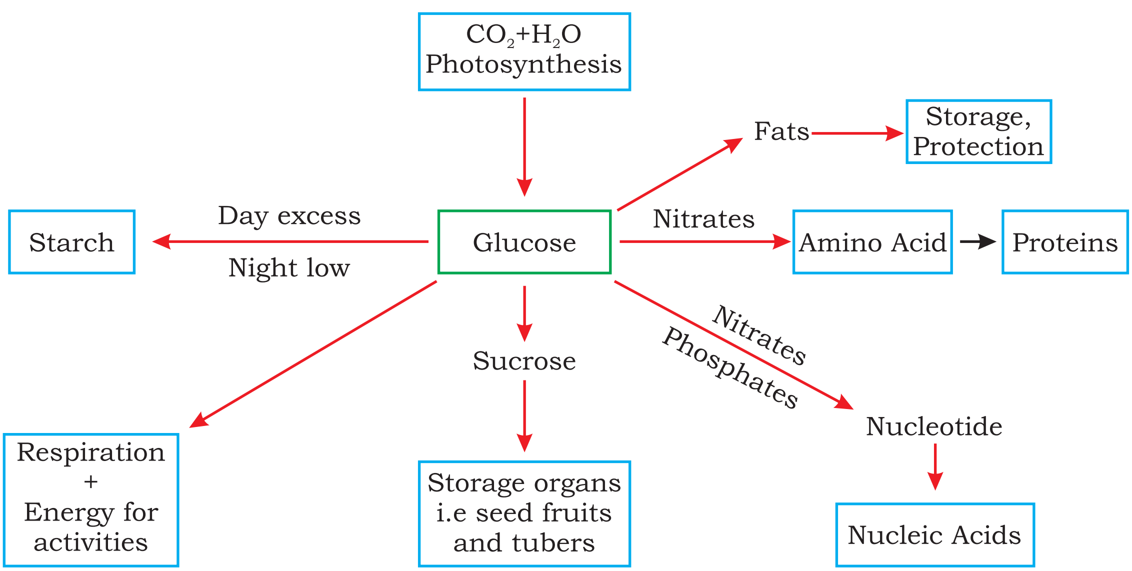
$$\text{Carbondioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Chlorophyll is the green pigments found in the chloroplast of plant cell. It captures a specific part of visible light only, therefore it is not a reactant but absorbs energy needed to drive the reaction. In other words photosynthesis converts light energy into chemical energy.

The fundamental molecule produced during photosynthesis is simple sugar i.e. Glucose. Glucose utilizes in most of the metabolism of plant to produce secondary products like starch and other polysaccharides. Plants also use carbohydrates to form fats, proteins and other chemical like Nucleic Acids.

This glucose is also used in respiration as reactant to produce energy for the metabolism of living organisms.



Different forms of life completely depends on Photosynthesis

Plants are not the only organisms which depend on photosynthesis but animals (Heterotrophs) also depend on phototrophs. These organisms utilize the molecules of phototrophs as food molecules. If an animal is herbivorous it feeds directly on plants. If an animal is carnivorous it depends on those animals which feed on plants. These feeding sequences and relationship are called Food Chains.

On the other hand photosynthesis is the only process which produces free O_2 by splitting water. This O_2 is utilized by all living organisms for respiration to produced energy for metabolism. Without O_2 living organisms cannot survive. Through Photosynthesis quantity of CO_2 and O_2 in nature is maintained by plants. During Photosynthesis plants fix CO_2 and release O_2 in environment.

CO_2 has a property to absorb heat of sun. If its quantity increases in environment, there will be increase in an environmental temperature on earth called Global warming. Photosynthesis keeps the quantity of CO_2 maintained in environment i.e. indirectly keeping the concentration of CO_2 to maintain the temperature of earth.

7.2.1 Chloroplast as light Trapping and storage organelle:

Green part of plants and algae contain special cell which contain special organelle called chloroplast. Chloroplast is a double membrane bounded organelle, have semi-fluid proteins containing medium called **Stroma**. Another network of membrane is also embedded in it called Thylakoid membrane, somewhere this thylakoid are piled at one another in stack called Grana (Singular - Granum).

The simple looking reaction of photosynthesis is not as simple as it looks. It involves number of chemical reactions which are catalyzed by number of enzymes, either in non cyclic or cyclic ways. Each reaction occurs at different site in chloroplast i.e.

1. Reaction in which light energy converted into chemical energy and stored in ATP (Adenosine Triphosphate) and $NADPH_2$ (reduced Nicotine amide Adenosine Dinucleotide Phosphate). This conversion occurs at thylakoid membrane where solar energy is captured by pigments located in harvesting complex. This phase of photosynthesis is called light Dependent reaction. It is non Cyclic process coupled with breakdown of H_2O molecules i.e. photolysis, takes place also at thylakoid membrane.

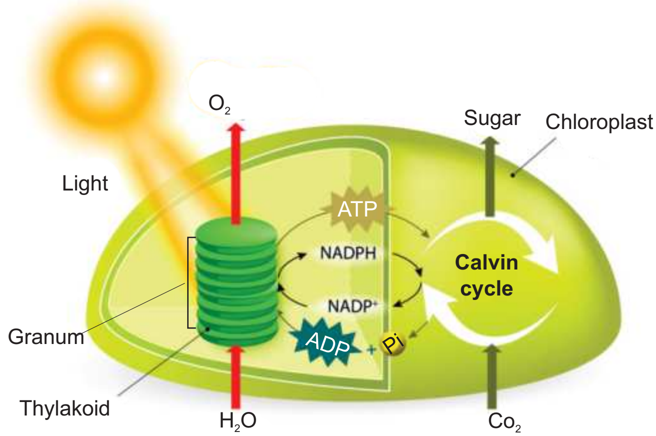


Fig: 7.2 Photosynthesis: light dependant and light independent phase in chloroplast

2. Reaction in which captured solar energy transferred to glucose from ATP and $NADPH_2$. It takes place in stroma, in cyclic manner. During this phase fixation of atmospheric CO_2 also takes place to form organic molecules.

7.2.2 Two phases of Photosynthesis:

Processes of Photosynthesis is mainly divided into phases or reactions.

1. Light Reaction or Light Dependent reaction.
2. Dark Reaction or Light Independent reaction

1. Light Reaction or Light Dependent Reaction

The term light reaction or light dependent reaction is used due to the reason that during this phase of photosynthesis light energy is captured and converted into chemical energy.

Some of the light is utilized to split water into oxygen and H^+ with e^- (electrons), this splitting of water is called Photolysis. Oxygen which is produced during photolysis is released in the environment where as H^+ together with CO_2 are used in building Glucose.

In chloroplast, different pigments absorb light of different wave lengths. Among them chlorophyll is the main light capturing molecules in thylakoid membrane which absorbs violet, blue and red light but reflects green therefore it appears green. In the thylakoid membrane other pigments and electron carrier molecules form highly organized assemblies in a series called photosystems. Each thylakoid contains

thousands of copies of two different kind of photosystems called photosystems I and II. Each consists of two major parts, a light harvesting complex and an electron transport system.

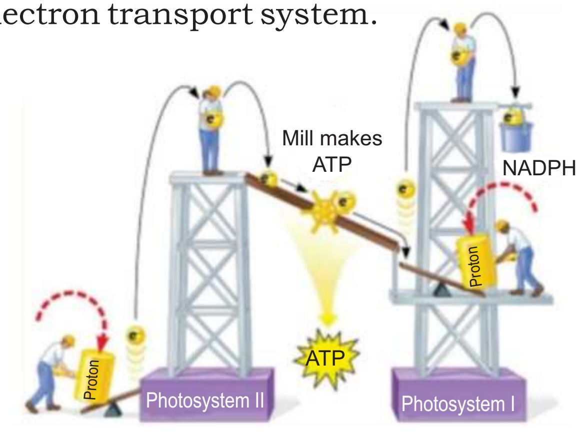


Fig: 7.3 scheme of light reaction

The conversion of light energy takes places when the chlorophyll of reaction center receives energy. One of the electrons from chlorophyll "a" molecule leaves and jump over the electron transport system. This energized electron moves from one e^- carrier to next. The electron releases energy, when it comes down, this energy drives reactions and produces two energy rich compounds. These are:

i) ATP (Adenosine Triphosphate)

ii) $NADPH_2$ (Reduced Nicotinamide Adenosine Dinucleotide Phosphate)

ADP is the compound which is already present in cell. It combines with phosphate by using energy of photon released from when moving through e^- carriers in photosynthesis.

$$ADP + P \xrightarrow[\text{Enzyme Complex}]{\text{Light energy}} ATP$$

NADP also present in chloroplast is reduced into $NADPH_2$ by accepting Hydrogen ions (H^+), released from splitting of water.

$$\underset{\text{Cell}}{NADP} + \underset{\text{From Water}}{\underbrace{2H^+ + 2e}} \longrightarrow \underset{\text{Reduced form}}{NADPH_2}$$

ATP and $NADPH_2$ both are energy rich compounds which provide energy, Hydrogen (H^+) and e^- for the conversion of atmospheric CO_2 into carbohydrates in chloroplast during light independent Phase of photosynthesis.

2. Dark Reaction or Light Independent Reaction:

This phase of photosynthesis does not require energy of photon but also takes place in day simultaneously with the light reaction. The ATP and $NADPH_2$ synthesized during the light dependent reaction are dissolved in stroma there, they provide energy to power the synthesis of Glucose from CO_2 and H_2O (i.e. H^+ and e^- of water). This Phase occurs independently, without light as long as ATP and $NADPH_2$ are available.

This phase of photosynthesis is cyclic phase. It occurs in set of reactions also called Calvin – Benson Cycle due to it's discover or the C_3 (three Carbon Containing Compounds formed initially) Cycle.

The C_3 Cycle requires

1) CO_2 - normally from air some of it also comes from respiration.

2) CO_2 Capturing Sugar - a Pentose Sugar.

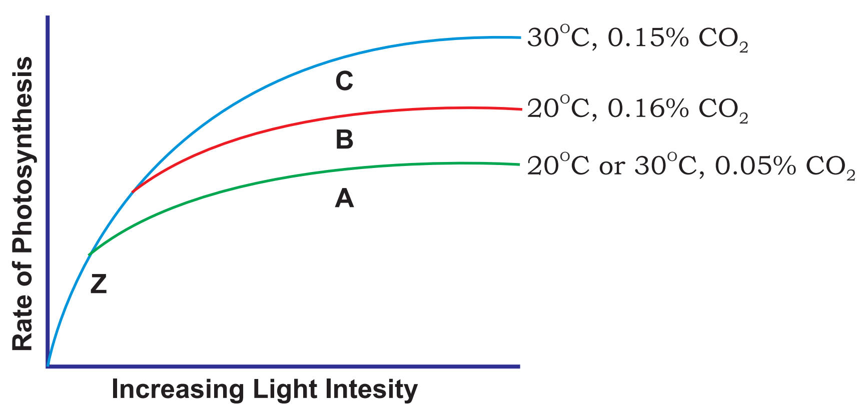
3) Enzymes to catalyze all the reactions.

4) Energy from ATP and $NADPH_2$ come from light dependent reaction.

7.2.3 Limiting Factor

Rate of biochemical reaction dependent on some factors which affect the rate are called limiting factor. For example at low light intensity rate of photosynthesis increase continuously but at high light intensity the rate becomes constant.

Light intensity, Carbon dioxide concentration and temperature can all be limiting factors for the rate of photosynthesis. Following graph shows the idea of limiting factor.



A- At point Z on graph, light intensity is limiting factor.

B- If light intensity increase to bright light and moderate temperature the concentration of CO_2, in air becomes limiting factor. It is clearly observed that the same plant if put into air containing high CO_2 then the rate of photosynthesis becomes high.

If there is high light intensity and high CO_2 concentration then the temperature becomes the limiting factor but the temperature should not be very high otherwise enzymes become denatured.

Activity: Find out the effect of light intensity on the rate of photosynthesis

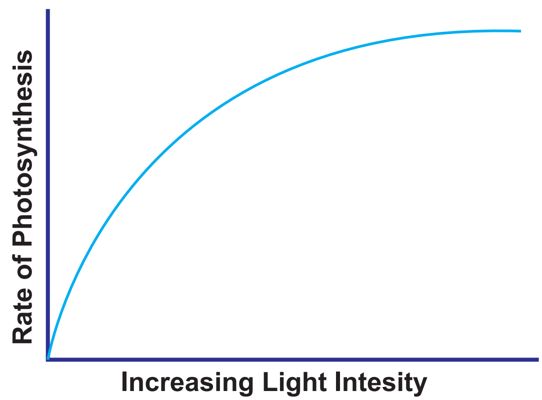
Apparatus:

Large beaker of water, boiling tube, stand and clamp, paper clip, fresh water plant hydrilla, ruler, stopwatch, thermometer, lamp etc.

Procedure:

1. Take a healthy piece of Hydrilla. Place it upside down in a boiling tube of water. It helps to sink the Hydrilla.
2. Clamp the tube to hold it upright in beaker of water. Ensure that the plant is perpendicular to source of light. The beaker of water is needed to maintain a constant temperature.
3. Place a thermometer in water to record the temperature. Turn off the room lights to reduce back ground light and place a bench lamp close to the beaker.
4. Observe the plant for few minutes, you will see the bubbles of gas coming out from the cut end of plant. If no bubbles are seen repeat the experiment by using fresh piece of plant. Count the number of bubbles per minute. If the rate of bubbling is too fast to count, move the lamp away from the breaker until the rate becomes countable.
5. Repeat the counts until you are sure that the rate is constant. Record the rate and the distance of the lamp from the plant.
6. Change the distance of lamp from plant and take more measurement of the rate of bubbling at each distance. Take 3 values at each point.
7. Repeat the counts at different distance from plant keep the temperature of water constant thought out the experiment.

Suppose that the rate of bubble production is the measure of the rate of photosynthesis. It is concluded that the rate of photosynthesis decreases at low light intensities. As the lamp is moved away from plant, the intensity of light falling on it also decreases.



7.3 RESPIRATION

To carry out all the life process cells requires energy. The source of this energy is food or photo assimilates (Products of photosynthesis) in plants. Cells break food molecules to release their Chemical energy. The breakdown of food molecules to release energy is called **respiration**.

Usually cells use oxygen to oxide food. It results CO_2 and water as waste products. The main food oxidized is the sugar i.e. Glucose. The overall equation for this chemical reaction is:

$$\text{Glucose} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{water} + \text{Energy}$$

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$$

Above equation shows that one molecule of glucose reacts with six molecules of oxygen to produce six molecules of carbon dioxide and six molecules of water. The main product is energy which is produced in the form of energy rich molecules called ATP.

It is commonly believed that breathing and respiration processes are same but factually they are different, although they are linked. As we have discussed above respiration is the chemical reaction takes place in cells to release energy from food while the breathing is the movement of air in and out of the organism to supply O_2 and CO_2. We use another term for breathing called Ventilation. Breathing allows the process of gaseous exchange at surface of cells and tissues. So the terms breathing, gaseous exchange and respiration are different from one another but linked together to make possible energy production at cellular level.

7.3.1 Type of Respiration

There are two types of respiration found in living organisms for the production of energy.

i) Anaerobic Respiration or Fermentation ii) Aerobic Respiration

(i) Anaerobic Respiration:

The primitive type of respiration which takes place in the absence of O_2 or without O_2 is called anaerobic respiration or fermentation. There are special conditions where O_2 is not available so the organisms adapt themselves to break down their food without oxygen which is called anaerobic respiration or fermentation. It takes place in some bacteria, fungi, endoparasite and sometimes in animal.

During anaerobic respiration, glucose is not broken down completely so less amount of energy (5 to 10% as compared to aerobic respiration) is released but it can sustain life even in the absence of O_2. It had evolved on earth where there was no O_2 on earth. There are two types of anaerobic respiration.

Alcoholic fermentation:

The bacteria and fungi respire aerobically but when these organisms are deprived of oxygen they stop respiration aerobically and start respiring anaerobically instead, During this anaerobic respiration they produce ethyl alcohol with CO_2.

$$\text{Glucose} \longrightarrow \text{Ethanol} + CO_2 + \text{Some energy}$$

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{Some ATP}$$

Acidic fermentation:

In animals when aerobic respiration is not enough to produced required energy they start anaerobic respiration. During this process glucose breaks down into a substance called **lactic acid**.

$$\text{Glucose} \longrightarrow \text{Lactic acid} + \text{Some energy}$$

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$$

A limited amount of energy is produced as compared to aerobic respiration but this is enough to power the athlete's muscles during start time of sprint. He experiences pain, this condition of pain is called Muscle fatigue. The lactic acid is produced in his muscles and bool stream.

Importance of anaerobic respiration:

As we have discussed earlier that anaerobic respiration is the emergency arrangement of energy which has an advantage that organisms can survive without O2 or can work for short period with same pace for short period. The other products of anaerobic respiration are acids. Vinegars are also organic acids that are produced commercially by acidic formulations.

Anaerobic respiration also produces ethyl alcohol. This process is commercially utilized by making alcoholic products like beer, wines and other beverages.

Baking industry is also based on it because anaerobic respiration also produces CO_2 which gives fluffy and soft shapes to cakes and breads also break down of starch into complex sugar to form bread and pizza.

(ii) Aerobic Respiration:

Type of respiration where food breakdown occurs in the presence of oxygen to produce energy. It is a method of respiration found in majority of organisms. It takes place in the presence of free oxygen, oxidizing the food and releasing the maximum amount of energy i.e. 2827 kj / mole of glucose or 36 ATP molecules/glucose.

The end products of aerobic respiration are CO_2 and H_2O

Glucose + oxygen $\longrightarrow$ Carbon dioxide + water + Energy (36 ATP)

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 36\ ATP$$

7.3.2 Mechanism of aerobic respiration:

Aerobic Respiration takes place in 3 steps at different places in the cell.

(a) Glycolysis (Gr. Glyco = Sugar, Lysis = Break down):

First stage is that stage where a molecule of glucose (Six carbon sugar) is broken down into two molecules of pyruvic acid (three carbon acid). It does not require oxygen. It takes place in both aerobic and anaerobic respiration. This splitting of glucose releases small amount of energy of glucose which is enough to generate 2 molecules of ATP. Glycolysis is a complex sequence of reaction all occur in cytosol.

(b) Kreb's or Citric acid Cycle:

The second stage of aerobic respiration in which pyruvic acid produced during glycolysis enters the mitochondria where O_2 available. Cellular respiration uses this O_2 to break pyruvic acid completely into CO_2 and H_2O in a cyclic manner. During Kreb's Cycle some ATP produce and some co-enzymes like NAD and FAD are reduced to $NADH_2$ and $FADH_2$. It takes place in matrix of mitochondria.

(c) Electron Transport Chain:

The last stage of aerobic respiration in which $NADH_2$ (Nicotinamide Adenosine Di-nucleotide) and $FADH_2$ (Flavinamide Adenosine Di-nucleotide) are oxidized to produce ATP and H_2O. It takes place at the cristae of mitochondria.

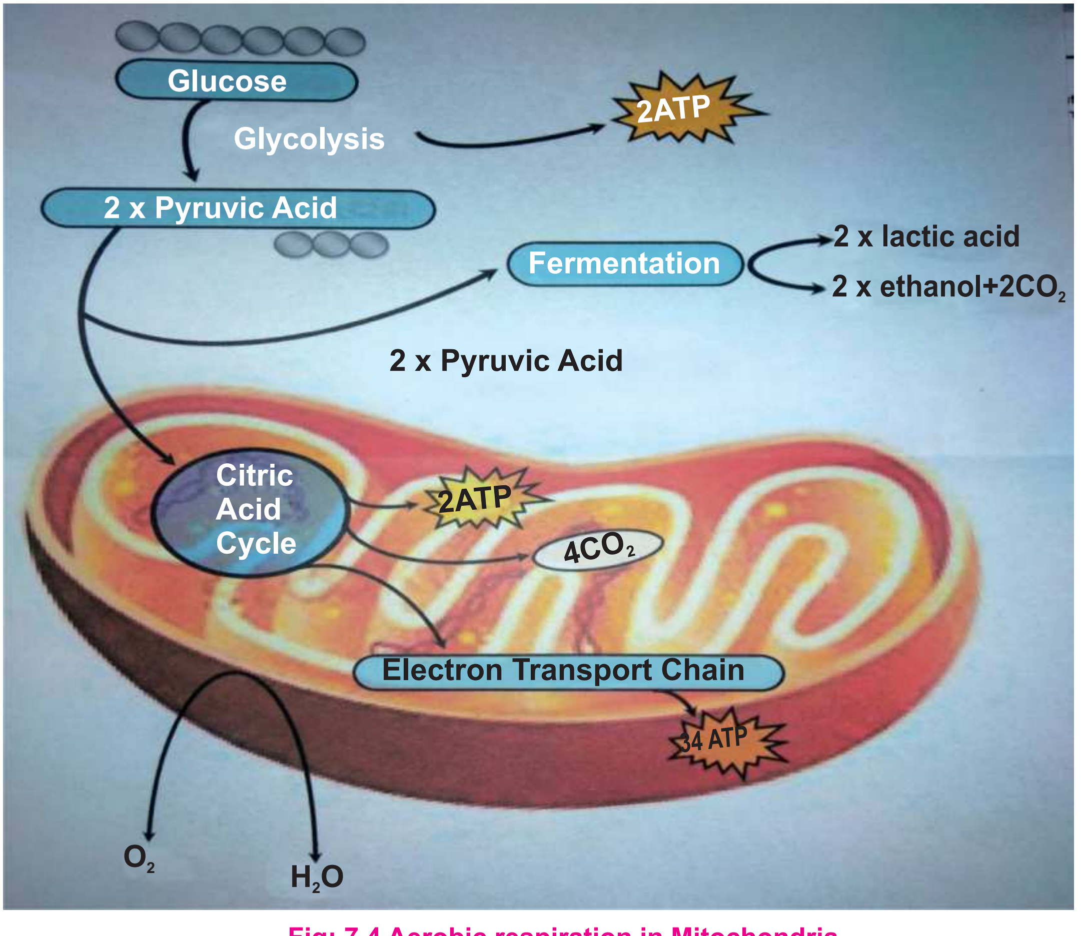


Fig: 7.4 Aerobic respiration in Mitochondria

7.3.3 Usage of Respiration Energy in the body of Organisms:

Number of Processes requires energy in the body of an organism. Body provides it from respiratory energy. Following are some process which utilize respiratory energy.

- Synthesis of molecules — Formation of different molecules as well as large molecules from small molecules requires energy.
- Cell division — During cell division formation of large molecules like DNA and protein takes place which require energy as well as movement of chromosome also require energy.
- Growth without cell division — enlargement growth is not possible and both require formation of molecules which require energy.
- Active transport — movement of ions and molecules from low concentration to high concentration requires energy.
- Muscle Contraction — Movement of muscle requires energy which is produced from chemical energy, chemical energy converted into kinetic energy.
- Passage of Nerve impulse — Nerve Impulse (message of Neuron) is basically electrical signals moving long nerve fiber by active transport requires energy.
- Maintenance of Body temperature — In higher animal's body temperature is maintained at constant level, this temperature maintenance requires energy of respiration.

Photosynthesis	Respiration
• Photosynthesis is the process where light energy converted in chemical energy.	• Respiration is the process where chemical energy converted into energy of ATP.
• It occurs only in chlorophyll containing organisms.	• It occurs in all organisms.
• It requires light sources i.e occur only in the presence of light.	• It does not requires light source so occurs throughout the life.
• It occurs in chloroplast.	• It occurs in mitochondria.
• The reactants are Carbon dioxide and water.	• Reactants are carbohydrates and oxygen usually.
• Products are glucose and	• Products are carbon dioxide and water in the case of aerobic

Summary

- The study about conversion of free energy into different forms by living organisms is called bioengergetic.
- Energy conversion takes place during oxidation reduction reaction.
- ATP is the source of energy for metabolic reaction in living organism. This energy comes from carbohydrate or oxidation process or from other molecules.
- Photosynthesis is the fundamental process in which basic organic molecule and oxygen (O_2) are produced.
- Chlorophyll is the green pigment found in chloroplast of plant cell. It captures specific part of visible light.
- The fundamental produce during photosynthesis is simple sugar i.e Glucose.
- Plant and other heterotrophes are also dependant on phototrophes.
- Photosynthesis is the only process which produce free O_2 by splitting H_2O.
- Photosynthesis is consists of two Steps:

  (i) Light dependent (ii) Light independent reaction
- Reaction in which light energy converted into chemical energy and stored in the form of ATP and $NADPH_2$. This step called light reaction.
- Light reaction occur at thylakoid membrane.
- Reaction where captured light energy converted into glucose from ATP and $NADPH_2$, takes place in stroma of Chloroplast.
- The formation of ATP from ADP by using light energy called phosphorylation.
- Rate of biochemical reaction dependent on some factors which effect the rate called limiting factor.
- Some limiting factors of photosynthesis are light intensity Co_2, concentration and temperature.

- Break down of food molecules to release energy in cell is called respiration.
- The energy of food molecules specially glucose produce as oxidation energy.
- The oxidation energy is stored in ATP.
- There are two types of respiration:

  (i) Anaerobic respiration (ii) Aerobic respiration
- Respiration which takes place in the absence of O_2 called Anaerobic respiration or fermentation.
- Alcoholic and acidic fermentation are the types of anaerobic respiration.
- Type of respiration takes place in the presence of O_2 called aerobic respiration.
- Aerobic respiration occur in three steps:

  (a) Glycolysis, (b) Kreb's Cycle and (c) e^- Transport chain.
- Glycolysis where glucose convert into pyruvic acid is cytosol.
- Kreb's cycle where breakdown of pyruvic acid takes place aerobically to produce CO_2 and energy stored in $NADH_2$ and $FADH_2$.
- e^- transport chain where oxidation of $NADH_2$ and $FADH_2$ occur the oxidation energy produce and stored in ATP. It occurs at Cristae of Mitochondria.

Review Questions

1. Encircle the correct answer:

(i) In an oxidation process 14135KJ energy is release, how many moles of glucose consume during this process.

(a) 1 (b) 3 (c) 5 (d) 10

(ii) Stage of aerobic respiration takes place at the cristae of mitochondria called.

(a) Electron transport chain (b) Glycolysis

(c) Kreb's cycle (d) C3 cycle

(iii) In a process of cellular respiration 180 ATP molecules are produced, how many moles of glucose consume during this process.

(a) 2 (b) 5 (c) 8 (d) 10

(iv) Loss of electron and proton is called

(I) Oxidation reaction (II) Reduction reaction

(III) Redox reaction

(a) I only (b) I and II (c) II and III (d) I, II and III

(v) Each mole of ATP store energy

(a) 7.3 kcal/mole (b) 7.3kj/mole

(c) 17.3kcal/mole (d) 17.3kj/mole

(vi) Fundamental molecule produced during photosynthesis is

(a) Glucose (b) Amino acid (c) Fatty acid (d) Nucleotide

(vii) Light dependent reaction takes place in

(a) Stroma (b) Thylakoid (c) Cristae (d) Cisternae

(viii) Reaction in which solar energy is transferred to glucose from ATP and $NADPH_2$, takes place in stroma called

(I) Light reaction (II) Dark reaction

(III) Light dependent reaction

(a) I only (b) II only (c) I and II (d) II and III

(ix) Splitting of water in presence of light called

(a) Hydrolysis (b) Glycolysis

(c) Photolysis (d) None of these

(x) Splitting of glucose (glycolysis) release small amount of energy which is enough to generate

(a) 2ATP (b) 5 ATP (c) 18 ATP (d) 36ATP

2. Fill in the blanks:

(i) The only source of energy on earth is_______.

(ii) Conversion of free energy into different forms by living organisms is called________.

(iii) In living organisms energy is stored in a special molecule called________.

(iv) Plant utilizes simple inorganic molecules (CO_2 and H_2O) to prepare _______.

(v) Feeding sequences and relationships are called ___________.

(vi) Photosynthesis is the only process which produces free O_2 by splitting________.

(vii) Chloroplast is double membrane bounded organelle have semifluid protein containing membrane called_______.

(viii) In chloroplast different pigments absorb light of different ___________.

(ix) The breakdown of food molecules to release energy is called _________.

(x) Each mole of glucose produce maximum energy i.e. ___________.

3. Define the following terms:

(i) Bioenergetics (ii) Energy (iii) Oxidation reaction

(iv) Food chain (v) Granum (vi) Photolysis

(vii) Fermentation (viii) Stroma (ix) Aerobic respiration

(x) Pyruvic acid

4. Distinguish between the following in tabulated form:

(i) Respiration and photosynthesis

(ii) Light reaction and Dark reaction

(iii) Aerobic respiration and anaerobic respiration

5. Write short answers of following questions:

(i) How CO_2 maintain the temperature of earth?

(ii) Why second phase of photosynthesis is called dark reaction?

(iii) How respiration is different from breathing?

(iv) Why acidic fermentation is harmful?

(v) How glucose form secondary products in plants?

6. Write detailed answers of the following questions:

(i) What is energy currency of cell? Describe chemical process of energy transmission.

(ii) Describe phases of photosynthesis with suitable diagram.

(iii) Describe aerobic respiration in living system.

NUTRITION

Chapter 8

Major Concept

In this Unit you will learn:

- Introduction
- Nutrition in Plants
  - Nutrition and Nutrients in Plant
  - Nutrients and Modes of Nutrition
  - Mineral Nutrition in Plants (Role of Nitrates and Magnesium and effects of their deficiencies)
- Heterotrophic Nutrition
- Nutrition in Man
  - Major Components of Food
  - Effects of Vitamins
  - Effects of Minerals
  - Effects of Water and Dietary fibers
  - Balanced Diet
  - Problems related to Nutrition
  - Protein Energy Malnutrition
  - Mineral Deficiency diseases
- Digestion in Man
  - Ingestion
  - Digestion
  - Absorption
  - Assimilation
  - Egestion
  - Role of liver in digestion
  - Absorption of Food (Structure of Villus)
- Disorders of Gut (Diarrhea and Constipation)



INTRODUCTION

Process by which organisms obtain and use the nutrients required for maintaining life is called nutrition. Essential substances that our body needs in order to grow and stay healthy are known as nutrients. There are two processes by which food is obtained or prepared such as:

- **Autotrophic nutrition** - it is the mode of nutrition in which an organism makes its own food from the simple inorganic materials like carbon dioxide, water and minerals present in the surrounding (with the help of energy). The processes are photosynthesis or either chemosynthesis.
- **Heterotrophic nutrition** - it is the mode of nutrition in which an organism can't make its own organic material but depends on other organisms for its food and use it for growth and energy.

Nutrition is the study of nutrients in food, how the body uses nutrients, and the relationship between diet, health, and diseases.



Figure 8.1 Nutrients

8.1 NUTRITION IN PLANTS

Plants and animals do not obtain food by the same processes. Plants and some bacteria have the green pigment chlorophyll to synthesize food, while animals, fungi and other bacteria depend on other organisms for food. Based on this, there are two main modes of nutrition: autotrophic and heterotrophic.

1. Autotrophic nutrition:

The term 'autotroph' is derived from two Greek words-autos (self) and trophe (nutrition). In autotrophic nutrition, an organism makes its own food from simple raw materials.

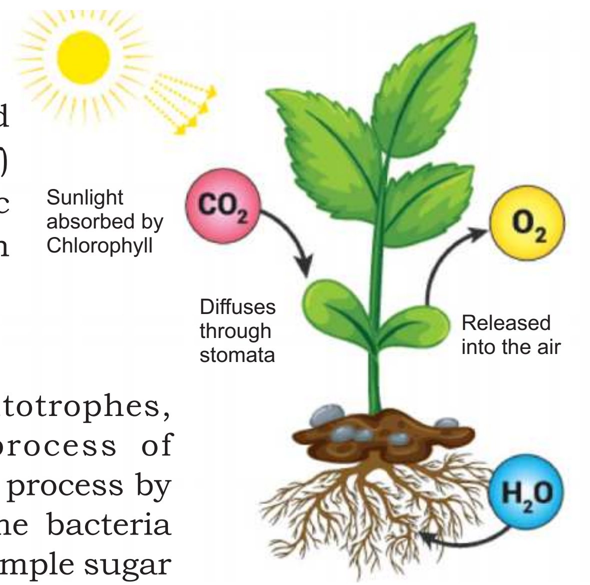


Figure 8.2
A summary of nutrition in green plants

Photosynthesis:

Green plants, which are autotrophes, synthesize food through the process of photosynthesis. Photosynthesis is a process by which green plants, algae and some bacteria having chlorophyll, synthesize the simple sugar (glucose) from the simple raw materials i.e. water and carbon dioxide by using the energy of sunlight. Oxygen is released in this process. The overall equation of photosynthesis is:

$$6CO_2 + 12H_20 \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

2. Heterotrophic nutrition:

The word 'heterotroph' is derived from two Greek words-heteros (other) and trophe (nutrition). Unlike autotrophes, which manufacture their own food, heterotrophic organisms obtain food from other organisms. As heterotrophs depend on other organisms for their food, they are also called consumers. All animals, non-green plants like and fungi come under this category.

Consumers which consume herbs and other plants are called herbivores, and those which consume animals are called carnivores. After taking complex organic materials as food, heterotrophs break them into simple molecules with the help of biological catalysts, i.e., enzymes and utilize them for their own metabolism.

Depending upon the mode of living and the mode of intake of food, heterotrophs may be parasitic, saprotrophic or holozoic.

(i) Parasitic nutrition:

Parasitic organisms, or parasites, live on or inside other living organisms, called hosts, and obtain their food from them. The host does not get any benefit from the parasite. This mode of nutrition is called parasitic nutrition. Different parasites, like Cuscuta (akash-bel), hookworms, tapeworms, leeches, etc., have different modes of feeding, depending upon habit, habitat and modifications.


Cuscuta


Cassytha


Leech


Tapeworm

Figure 8.3 Parasites

(ii) Saprotrophic nutrition:(Gr: Sapros=rotten, Trophic=nutrition)

Saprotrophic organisms, or saprotrophes, derive their food from dead and decaying organic material. This mode of nutrition is called saprotrophic nutrition. They secrete enzymes that are released on food material outside their body. These enzymes break down complex food into simple forms. Common examples of saprotrophes are fungi (moulds, mushrooms, yeasts) and many bacteria.

(iii) Holozoic nutrition: (Gr:Holo=Whole, Zoikos=of animal)

In holozoic nutrition complex organic substances are ingested (taken in) without their being degraded or decomposed. After intake, such food is digested by enzymes produced within the organism. Digested food is absorbed into the body and the undigested product is egested (expelled out) from the body. This kind of nutrition is found mainly in non-parasitic animals-simple ones like Amoeba and complex ones like human beings.

How organisms obtain nutrition?

Different organisms obtain food in different ways. Nutrition in unicellular organisms like Amoeba, involves ingestion by the cell surface, digestion and egestion.

Amoeba takes in complex organic matter as food. Amoeba first identifies its food then throws out a number of small pseudopodia (projections of cytoplasm, also called false feet). These pseudopodia enclose the food particle and prevent it from escaping. The food enclosed in the cell membrane forms a food vacuole.

The complex food is broken down into simpler molecules with the help of digestive enzymes produced by an organelle called lysosome. The digested food is distributed in the cytoplasm and the undigested food is egested through the cell membrane.

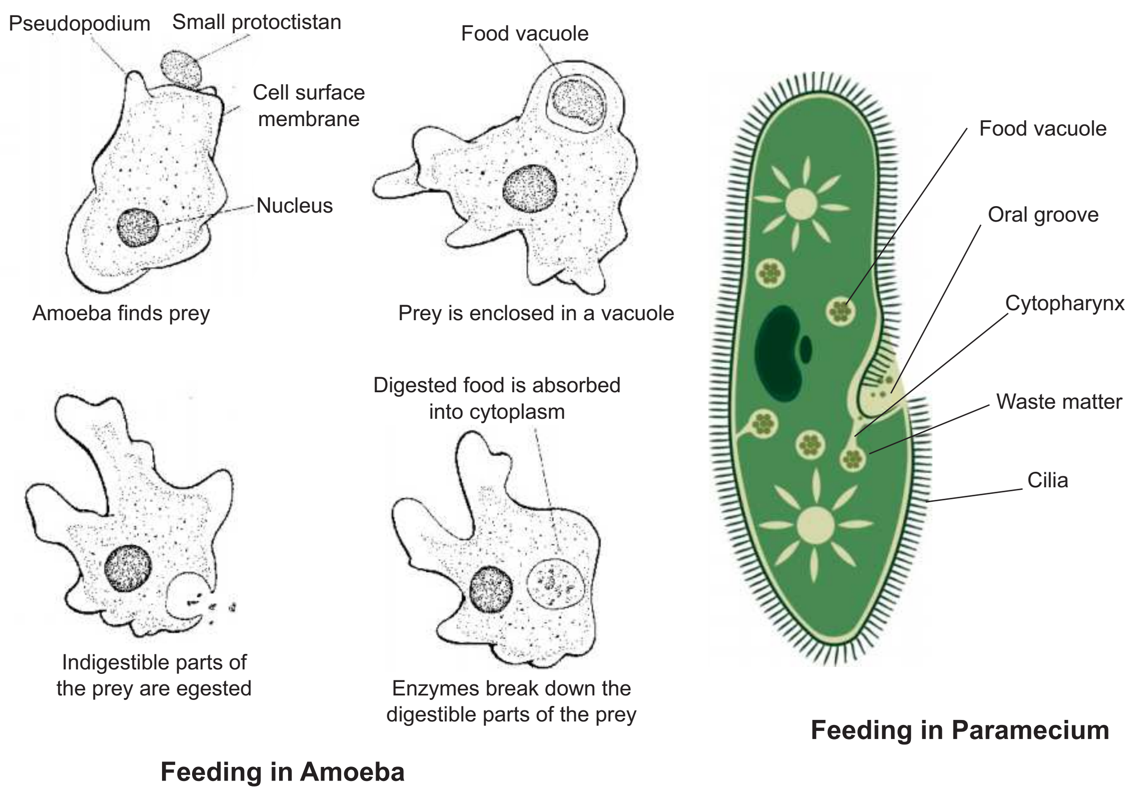


Figure 8.4 Food gathering by Amoeba and Paramecium

In Paramecium, a unicellular organism with a specific shape, food is ingested through a special opening, the cytostome (cell mouth). Food is brought to this opening by the lashing movement of cilia that cover the entire surface of the cell.

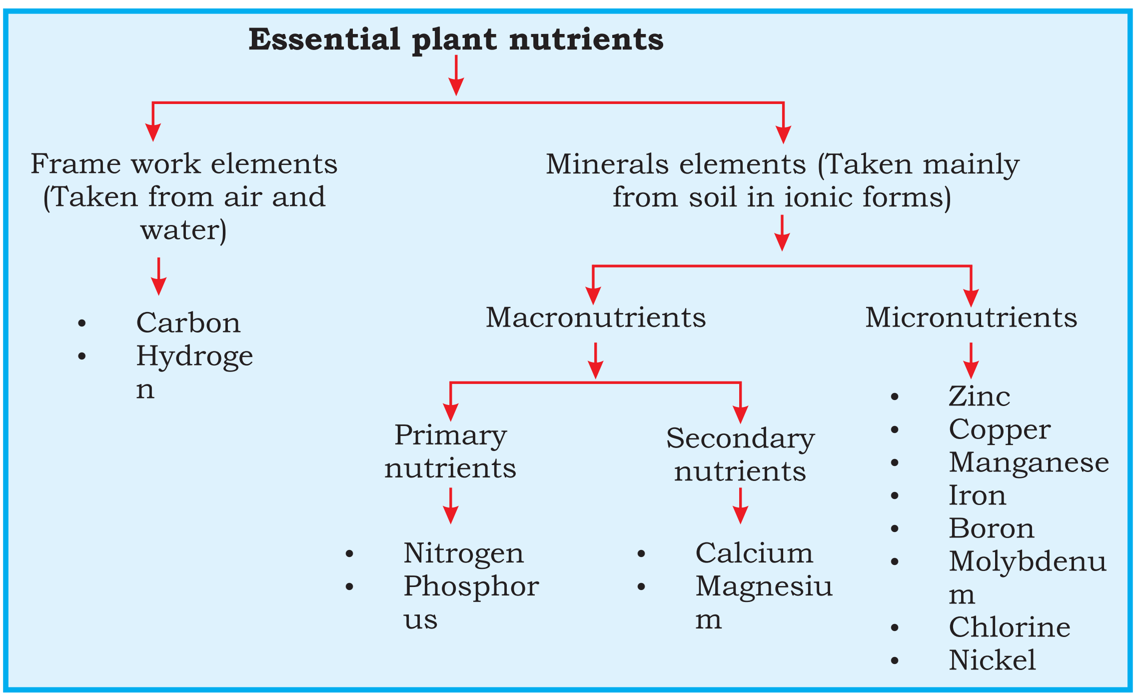
Mineral nutrition in plants:

The process involving the absorption, distribution and utilization of mineral substances by the plants for their growth and development is called mineral nutrition.

Plants have the most efficient mechanism for preparing there food by using many elements essential for plant nutrition. Plants require a steady supply of macronutrients and micronutrients. The difference between the two is quite simple: macronutrients are required in larger quantities than micronutrients.

The names of the two categories don't apply, indicate that one type of nutrient is more important than another; it just means that more macronutrients must be present in the soil than micronutrients. Plants obtain nearly all of the nutrients they need from the soil, although some are synthesized or produced via photosynthesis.

Classification of essential plant nutrients



8.1.1 Role of Nitrogen and Magnesium:

(i) Nitrogen

Nitrogen is essential for plants to synthesize amino acids, which are the building blocks for protein synthesis and also required for the production of chlorophyll, nucleic acids, and enzymes. From all metabolic elements which plants use from soil, nitrogen needs in the largest amounts.

Symptoms of nitrogen deficiency:

Nitrogen-deficient plants exhibit stunted growth, reduced yields and their foliage pale green.

(ii) Magnesium:

Many enzymes in plant cells require magnesium in order to perform properly and is a constituent of the chlorophyll molecule, which is the driving force of photosynthesis.

Symptoms of magnesium deficiency:

Magnesium deficiency is most prevalent on sandy-textured soils, which are subject to leaching, particularly during seasons of excess rainfall. The predominant symptom is **interveinal chlorosis** (dark green veins with yellow areas between the veins). The bottom leaves are always affected first as shown in figure 8.5.

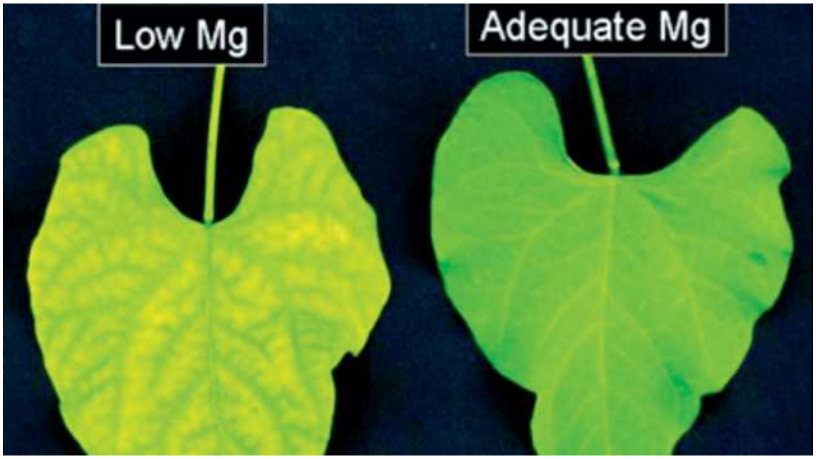


Figure 8.5 Interveinal chlorosis

8.1.2 Importance of fertilizers:

Fertilizers are substances containing chemical elements such as manure or mixture of nitrates that improves the growth of plants. They give nutrition to the crops and produce more fruit, faster growth, more attractive flowers. When added to soil or water, plants can develop tolerance against pests like weeds, insects and diseases. And the use of manure and composts as fertilizers is probably almost as old as agriculture. Modern chemical fertilizers include one or more of the three elements that are most important in plant nutrition: nitrogen, phosphorus, and potassium. Chemicals fertilizers are simply plant nutrients applied to agricultural fields to supplement required elements found naturally in the soil.

8.1.3 Environmental hazards related to chemical fertilizers:

An environmental hazard is a condition, which has the potential to threat natural environment or adversely affect people's health, including pollution and natural disasters.

The farmers apply fertilizer for better growth of their crops, but on the other side these fertilizers pollute water and soil as well.

1. Soil nutrient holding capacity:

The massive quantities of inorganic fertilizers affect the soil nutrient holding capacity.

2. Eutrophication:

The high solubility of fertilizers also degrade ecosystem through eutrophication (means an increase in chemical nutrients typically compounds containing nitrogen or phosphorus in an ecosystem).

3. Emission of greenhouse gas:

Storage and application of some nitrogen fertilizers may cause emission of greenhouse gas, e.g nitrous oxide.

4. Soil acidity:

Ammonia gas (NH_3) may be emitted from applied inorganic fertilizers. This extra ammonia can also increase soil acidity.

5. Pest problems:

Excessive nitrogen fertilizers can lead to pest problem by increasing their reproduction rate.

6. Nutrient balance:

It is recommended that nutrient content of the soil and nutrient requirement of crop should be carefully balanced with application of inorganic fertilizers. It is critical to apply no more than it is needed; any excess in nutrient will definitely develop pollution of any kind.

8.1.4 Components of Human Food:

Holozoic nutrition is the type of heterotrophic nutrition. Heterotrophic organisms have to acquire and take in all the organic substances they need to survive. There are seven major classes of nutrients: carbohydrates, protein, fats, minerals, fiber, vitamins, and water.

1. Carbohydrates:

Carbohydrates are necessary for your body specially glucose, which is primary source of energy. They are generally divided in two categories: simple carbohydrates such as sucrose, which digest quickly and complex carbohydrates such as starch etc, which digest slowly. Sources of simple carbohydrates include fruits, sugars and processed grains, such as white rice or flour. You can find complex carbohydrates in green or starchy vegetables, potatoes, whole grains, beans and lentils. The most common and abundant forms are sugars, fibers, and starches.



Figure 8.6 The food rich in carbohydrates

2. Proteins:

Proteins consist of units called amino acids, attach together in complex formations. Proteins are complex molecules, the body takes longer to break them down. As a result, they are much slower and long lasting source of energy than carbohydrates.

Proteins



Figure 8.7 The food rich in proteins

There are 20 amino acids. The body synthesizes some of them from components within the body, but it cannot synthesize 9 of the amino acids called essential amino acids. They must be consumed in the diet.

The body needs protein to maintain and replace tissues and their function. Protein is not usually used for energy. However, if the body is not getting enough calories from other nutrients or from the fat stored in the body, protein is used for energy.

The energy obtained from carbohydrates, proteins, and fats is measured in units called calories.

3. Fats:

Fats are complex molecules composed of fatty acids and glycerol. The body needs fats for growth and energy. It also uses them to synthesize hormones and other substances needed for the body's activities.



Figure 8.8 The food rich in fats

Fats are the slowest source of energy but the most energy-efficient form of food. The body deposits excess fat in the abdomen (omental fat) and under the skin (sub cutaneous fat) to use when it needs more energy. The body may also deposit excess fat in blood vessels and within organs, where it can block blood flow and damage organs, often causing serious disorders.

Some typical sources of saturated fats include:

- Fatty cuts of beef and lamb.
- Poultry skin.
- High fat dairy foods (whole milk, butter, cheese, sour cream, ice cream)
- Tropical oils (coconut oil, palm oil, cocoa butter)

Function of each food type in Human body

Carbohydrates	(i) Sugar	→	**For energy**
	(ii) Starch	→	**For energy**
	(iii) Fibre	→	**Prevents constipation**
Protein		→	**For growth and repair of cells**
Fat		→	**For energy and insulation**
Vitamins	(i) Vitamin C	→	For healthy skin/gums
	(ii) Vitamin D	→	For strong bones
Minerals	(i) Calcium	→	For strong bones
	(ii) Iron	→	To make red blood cells
Water		→	To dissolve and transport substances

4. Vitamins

A vitamin is an organic molecule (or related set of molecules), an essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism. They are for maintaining normal health and development. Lack of vitamins can cause several diseases. They are divided into two types:

(i) Fat-soluble Vitamins: Vitamin which can soluble in organic solvent are called Fat-soluble vitamins (A, D, E and K) are less excreted from the body as compared to water-soluble vitamins.

(ii) Water soluble Vitamins: Vitamin which are soluble in H_2O. These are vitamins B and C. Cooking or heating destroys the water soluble vitamins more readily than the fat-soluble vitamins.

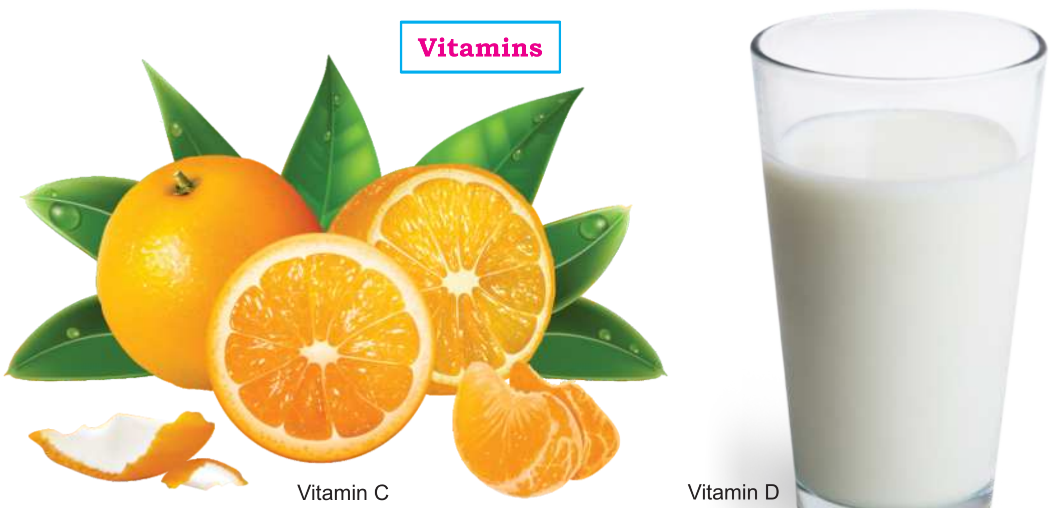


Figure 8.9 The food rich in Vitamins

Functions, chemical names and deficiencies of important vitamins

Vitamin generic name	Deficiency diseases
Vitamin K	Bleeding disorder
Vitamin D	Rickets and osteomalacia
Vitamin C	Scurvey
Vitamin B	Beriberi
Vitamin A	Night blindness, eye-infection, rough skin, respiratory infections

5. Minerals:

A class of naturally occurring solid inorganic substances with a characteristic crystalline form. Minerals are vital for proper human health.

Essential minerals include calcium, iron, zinc, iodine and chromium. Deficiencies can result in serious health conditions such as brittle bones and poor blood oxygenation. Minerals are found in a variety of foods including dairy and meat products.

Metabolic function of Calcium:

Calcium metabolism refers to the movements and regulation of calcium ions (Ca^{+2}) in and out of various body compartments. Good calcium nutrition, along with low salt and high potassium intake, prevents from hypertension and kidney stones.

- **Sources of calcium include:**
  - Milk, cheese and other dairy foods
  - Soya beans
  - Bread
  - Green leafy vegetables
  - Nuts
  - Fish

Calcium



Figure 8.10 The food rich in Calcium

Deficiency symptoms of calcium:

- Fainting
- Heart failure
- Numbness and tingling sensations around the mouth or in the fingers and toes
- Difficulty swallowing
- Voice changes due to spasm of the larynx
- Chest pains
- Wheezing
- Muscle cramps, particularly in the back and legs; may progress to muscle spasm (tetany)

Metabolic function of iron:

Iron plays a major role in oxygen transport and storage. It is a component of haemoglobin in red blood cells and myoglobin in muscle cells.

Some of the best plant and animal sources of iron:

- Beans and lentils
- Tofu
- Dark green leafy vegetables such as spinach

Deficiency symptoms of iron:

- Extreme fatigue
- Pale skin
- Chest pain, fast heart beat or shortness of breath
- Brittle nails
- Weakness
- Headache, dizziness
- Inflamation or soreness of tongue
- Poor appetite in infants

6. Metabolic function of Water and Dietary fibres:

Water is the medium for various enzymatic and chemical reactions in the body. It moves nutrients, hormones, antibodies and oxygen through the blood stream and lymphatic system. Water maintains the body temperature through evaporation as in sweating. Severe dehydration causes cardio-vascular problems.

Water



Figure 8.11 The Water

Generally speaking, dietary fiber is the edible part of plants, or similar carbohydrates, that can't be digested and absorbed in the small intestine. Fibre plays very important role to prevent from constipation. Soluble fibre helps in lowering the blood cholesterol and blood sugar level.

To get the proper nutrition from your diet, you should consume the majority of your daily calories in: fresh fruits and fresh vegetables.

8.2 A BALANCED DIET IS RELATED TO AGE, SEX AND ACTIVITY

Different factors affect the nutritional requirement during the periods of body growth & development. Energy requirements change through life and depend on many factors, such as: Age; Sex and Level of activity.

The key stages in life include:

Childhood; the energy requirements of children increase rapidly because they grow quickly and become more active. Young children do not have large stomachs to cope with big meals. Therefore, to achieve the relatively high energy intake for their age, foods should be eaten as part of small and frequent meals.

Adolescence; is a period of rapid growth and development and is when puberty occurs. The demand for energy and most nutrients are relatively high. Boys need more protein and energy than girls for growth.

Children should be encouraged to remain a healthy weight with respect to their height.



Figure 8.12 Balance Diet

Adulthood; a good supply of protein, calcium, iron, vitamin A and D, as part of a healthy, balanced diet, are important. Calcium is needed for healthy tooth development, and together with vitamin D, can help develop strong bones.

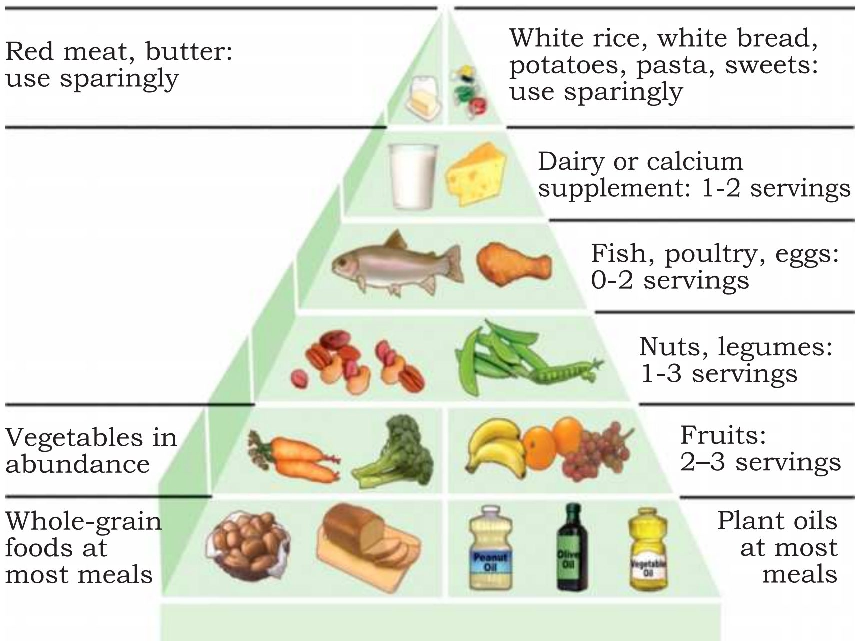


Figure 8.13 Healthy Eating Pyramid

Men are more active than women so they need more energy than women of same age group. Muscular tissues are more in men, their body size is larger, and therefore, boys of growing age need more body building nutrients (Proteins, Calcium) as compared to girls of same age.

8.2.1 Problems related to nutrition (Malnutrition):

Problems related to nutrition are grouped as malnutrition. The malnutrition is a condition that occurs when a body does not get enough nutrients. Malnutrition results from a poor diet or a lack of food. It happens when the intake of nutrients or energy is too high, too low, or poorly balanced. Consuming less than 2100 calories a day, one is considered to be under-nourished and suffering from hunger.

According to the World Health Organization (WHO), malnutrition is the gravest single threat to global public health. Globally, it contributes to 45 percent of deaths of children aged less than 5 years.

There are two types of malnutrition:

Chronic malnutrition: characterized by delayed growth in the children.

Acute malnutrition: Characterized by insufficient weight in relation to the child's height (emaciation). Acute malnutrition can be moderate or severe according to the child's weight.

Under-nourishment and malnutrition have serious consequences for the health of the younger children. Worldwide, three nutrient deficiencies are of particular concern:

- Vitamin A deficiency is the world's most common cause of preventable child blindness and vision impairment.
- Iron deficiency is associated with decreased cognitive abilities and resistance to disease.
- Iodine deficiency is the major preventable cause of mental retardation worldwide.

Malnutrition is one of the most prevalent public health problems in Pakistan. It is one of the major underlying factors for high infant and under 5 mortality rate in Pakistan. Poverty, lack of education, poor environmental hygiene and food fads are some of the reasons for its high prevalence in Pakistan.

8.2.2 Protein deficiency disorders:

Protein energy malnutrition (PEM) refers to inadequate availability or absorption of energy and proteins in the body. It is the leading cause of death in children in developing countries. PEM may lead to diseases such as;

(a) Kwashiorkor:

Kwashiorkor is a severe form of malnutrition, caused by a deficiency in dietary protein. The extreme lack of protein causes an osmotic imbalance in the gastro-intestinal system causing swelling of the gut diagnosed as an edema or retention of water as shown in figure 8.14.

(b) Marasmus:

Marasmus is a form of severe malnutrition characterized by energy deficiency. It can occur in anyone with severe malnutrition but usually occurs in children. A child with marasmus looks emaciated. Body weight is reduced to less than 62% of the normal (expected) body weight for the age as shown in figure 8.14.

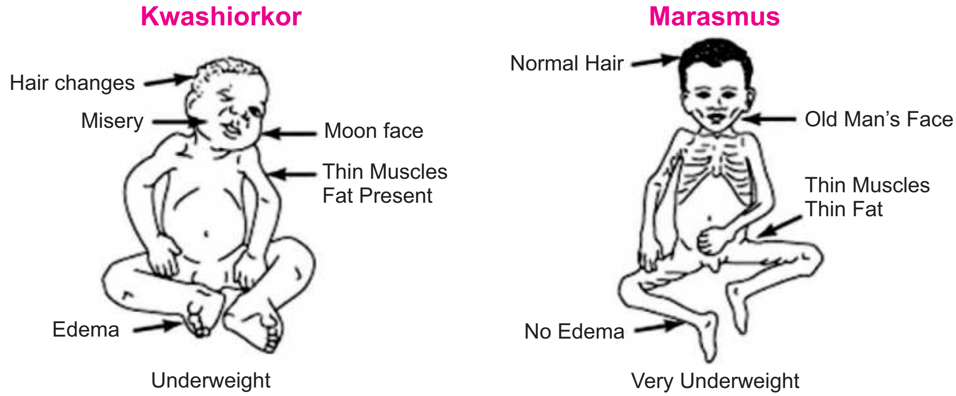


Figure 8.14 Characteristics of kwashiorkor and marasmus

8.2.3 Mineral deficiency disease:

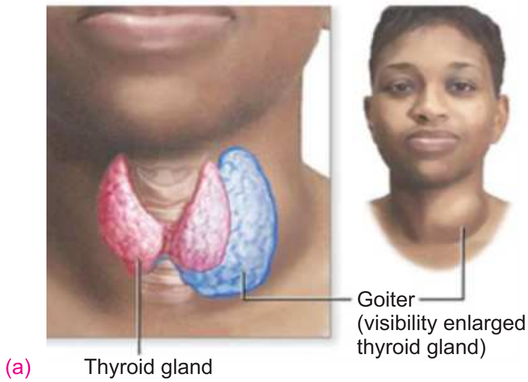
Diseases resulting from deficiency of a mineral are relatively rare among humans some are given below;

1. Goiter:

Goiter is a condition in which thyroid gland becomes enlarged and it results in swelling in neck. Goiter is caused by an insufficient amount of "Iodine" in diet. Iodine is used by thyroid gland to produce hormones that control the body's normal functioning and growth.

2. Anemia (most common of all mineral deficiency diseases):

The term anemia literally means "a lack of blood". The condition is caused when number of red blood cells reduced to a level lower than normal. Haemoglobin molecule contains four atom of iron. If body fails to receive sufficient amount of iron, an adequate number of haemoglobin will not be formed. So, there are not enough functioning red blood cells. A person becomes weak and there is shortage of oxygen supply to body's cells.



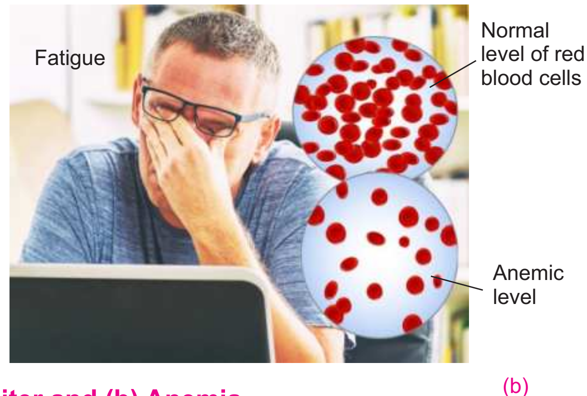


Figure 8.15 (a) Goiter and (b) Anemia

3. Over intake of nutrients:

It is a form of malnutrition in which more nutrients are taken than the amount required for normal growth, development and metabolism. The effects of over-intake of nutrients are usually intensified when there is reduction in daily physical activity (decline in energy expenditure). High intake of carbohydrates and fats leads to obesity, diabetes and cardiovascular problems. Similarly, high dose of vitamin A causes loss of appetite and liver problems. Excess dose of vitamin D can lead to deposition of calcium in various tissues.

8.2.4 The Effects of Malnutrition

Malnutrition hurts people both mentally and physically. The more malnourished a person is; the more nutrients the person is missing, the more likely person will experience health issues. Some of them are given below:

1. Starvation:

It is a severe deficiency in caloric energy intake. It is the most extreme form of malnutrition. In humans, prolonged starvation can cause permanent organ damage and eventually, death.

2. Heart diseases:

The term "heart disease" is often used interchangeably with the term "cardiovascular disease." Cardiovascular disease generally refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke. Heart problems occur in those people who take unbalanced diet. Fatty foods increase blood cholesterol level. It obstructs the blood vessels leading to heart diseases.

3. Constipation:

People do not schedule their meals. This irregularity cause many health problems like constipation. It can be well defined, a condition in which there is difficulty in emptying the bowels, usually associated with hardened faeces.

4. Obesity:

It is a medical condition in which excess body fat has accumulated to the extent that it may have a negative effect on health. Obesity is most commonly caused by a combination of excessive food intake, lack of physical activity, and genetic susceptibility. Obesity is known as mother-disease and may lead to heart problems, hypertension, diabetes etc.

8.2.5 Social problems related to malnutrition:

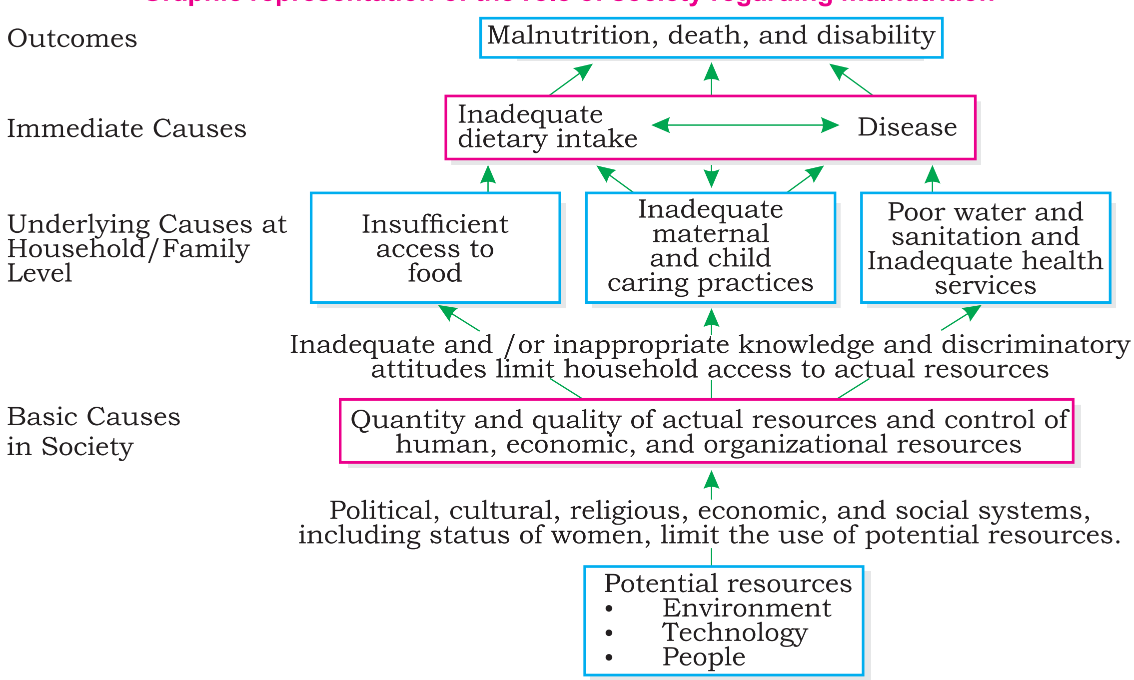
Chronic malnutrition disables and even kills its victims. The World Health Organization (WHO) believed that malnutrition is a causative factor in nearly half of the 10.4 million deaths among children under age five in developing countries. An adequate amount of food or dietary energy supply is necessary to enjoy a healthful and productive life. Malnutrition is not a simple problem with a simple solution. It results from the complex interplay of social and biomedical factors.

1. Food insecurity:

Food insufficiency refers to insufficient food supplies to meet minimum daily diet requirement.

Several countries in Africa and parts of other developing countries do not produce enough food to keep up with the food needs and increased population. Not only do they not produce sufficient food supplies to meet their own needs, but they are economically unable to purchase available food from the exporting countries, which has led to food insecurity in poor countries; as a result, millions are hungry and malnourished. Besides these problems drought (lack of water) and flood (over flow of water) play terrible role in decreasing crop yields.

Graphic representation of the role of society regarding malnutrition



Despite the profound effects of malnutrition problems on human and social developments, the world has shown only limited public alarm.

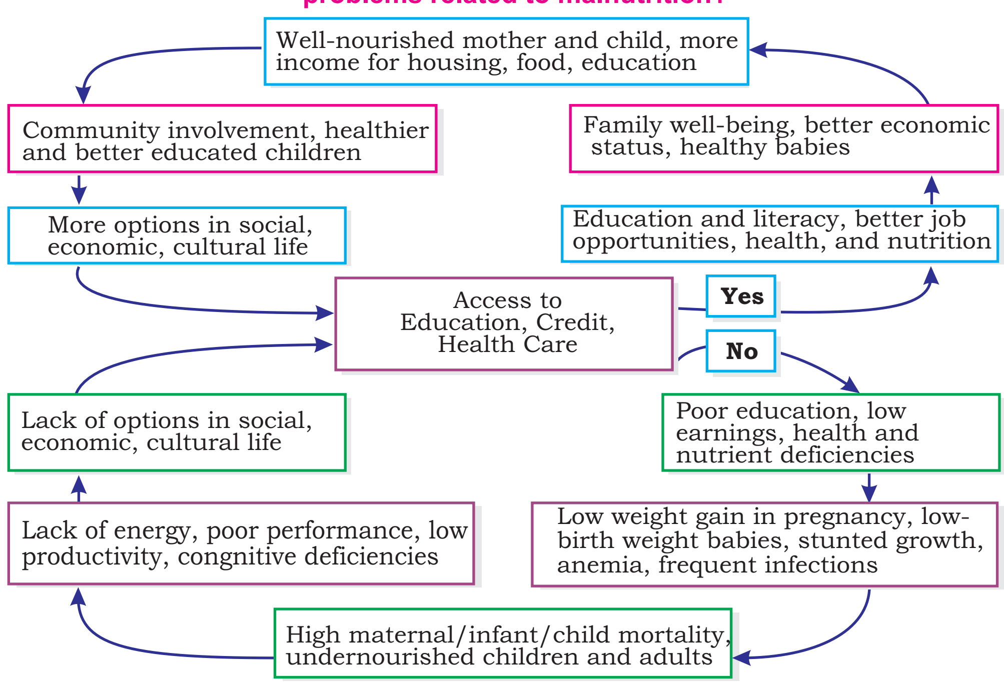
2. Poverty:

For various reasons people in developing countries are increasingly unable to produce enough food to meet their own needs. To meet the ongoing demand for food, food-deficit countries (those unable to produce sufficient food to meet their needs) must import additional food and make it available to people. Even if there is an abundance of food, some people may not have access to it, because more and more, access to food in developing countries is determined by household income.

3. Inequality

Because of a cultural preference for men over women in many developing countries, many women risk malnutrition throughout their lives. The risk for malnutrition in girls begins at an early age. Although nutritional needs are the same for boys and girls in the first 10 years of life, boys often get more food than girls do.

Graphic representation: how to overcome social and economic problems related to malnutrition?



4. Risk of infection:

The normal human body has the capacity to resist foreign organisms or toxins through the immune system, but the immune system ceases to function properly when the body is malnourished. When the immune system (the general process of body) is compromised by malnutrition, the skin's ability to resist the invasion of organisms, the acid secretion produced by the stomach to resist foreign agents, or the production of chemical compounds in the blood that destroy toxins can be affected adversely.

8.3 THE DIGESTIVE SYSTEM OF HUMAN

Digestion is important for breaking down food into nutrients, which the body uses for energy, growth, and cell repair. Food and drinks must be changed into smaller molecules of nutrients before the blood absorbs them and carries them to cells throughout the body.

> Digestion is the process in which large and non-diffusible molecules of food are converted into smaller and diffusible molecules that can cross the membranes.

After absorption of the digestible material, indigestible material expelled out of the body through the process of egestion.

Alimentary canal of human:

The digestive system is made up of the alimentary canal and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal (also called the digestive tract) is the long tube of organs - including the esophagus, stomach, and intestines - that runs from the mouth to the anus. An adult's digestive tract is about 30 feet (about 9 meters) long.

The digestion consists of following steps:

Ingestion: Intake of food.

Propulsion: Peristalsis-alternate waves of muscular contraction and relaxation in the primary digestive organs. The end result is to squeeze food from one part of the system to the next.

Mechanical Digestion: Physical preparation of food for digestion.
Segmentation: Mixing of food in the intestines with digestive juices.
Chemical Digestion: Carbohydrates, Fat, and Proteins are broken down by enzymes.
Absorption: Transfer of the digested portion of food into the blood from the digestive canal.
Egestion (Defecation): Removal/elimination of the waste products from the body.

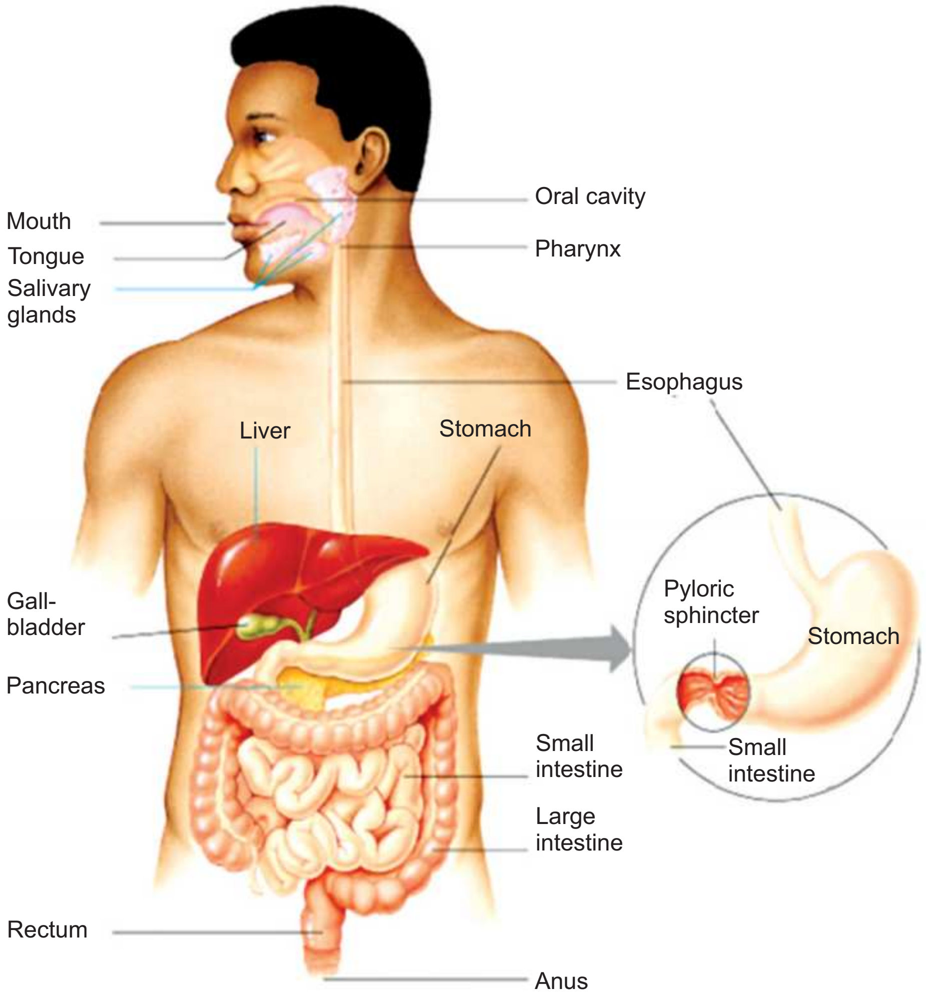


Figure 8.16 The human alimentary canal

Functions of oral cavity

Digestion begins in the oral cavity, well before food reaches the stomach. When we see, smell, taste, or even imagine a tasty snack, our three pairs of salivary glands, which are located under the tongue and near the lower jaw, begin producing saliva. This flow of saliva is co-ordinated with a brain reflex that triggered when we sense food or think about eating. In response to this sensory stimulation, the brain sends impulses through the nerves that control the salivary glands, telling them to prepare for a meal. Oral cavity is the space behind mouth in-between upper and lower jaw and has many important functions:

Food Selection: When food enters the oral cavity it is tasted and felt. Here food is selected or rejected due to the taste, hard object or dirt. Smell and vision also help in selection.

Grinding of food: The second function of oral cavity is the grinding of food by teeth. It is known as chewing or mastication. It is useful because oesophagus can pass only small pieces through it as well as enzymes cannot act on large pieces of food.

Lubrication of food: The third function of the oral cavity is lubrication of food by mixing saliva secreted by saliva. It has two main functions. (i) Adds water and mucus to the food. (ii) Partial digestion of starch by saliva which contains an enzyme salivary amylase.

Chemical digestion: Saliva contains an enzyme salivary amylase which helps in the digestion of starch partially. Than the pieces of food are rolled up by the tongue into small, slippery, spherical mass called bolus.

Swallowing of the bolus: Swallowing is accomplished by muscle movements by the tongue and mouth, food moves into the throat, or pharynx.

Functions of Pharynx and Oesophagus

The pharynx, a passageway for food and air, is about 5 inches (12.7 centimeters) long. A flexible flap of tissue called the epiglottis reflexively closes over the windpipe when we swallow to prevent choking. From the throat, bolus travels down a muscular tube in the chest called the esophagus.

Waves of rhythmic movements of muscle contractions and relaxation called peristalsis force down food through the oesophagus to the stomach. A person normally isn't aware of the movements of the esophagus, stomach, and intestine that take place as food passes through the digestive tract.

At the end of the oesophagus, a muscular ring called a sphincter allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the oesophagus.

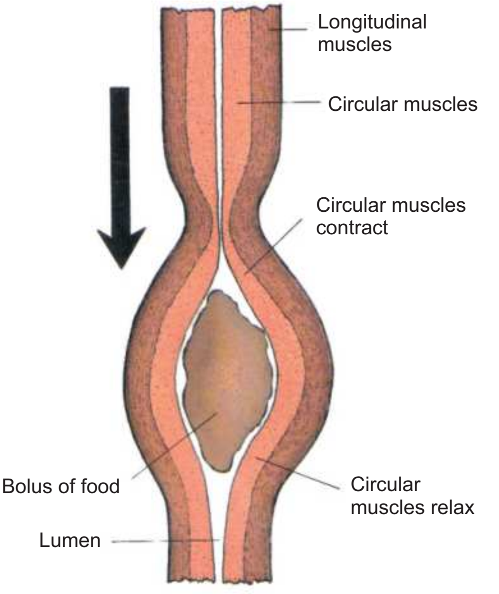


Figure 8.17 Peristalsis

Functions of stomach:

Stomach is j-shaped thick walled, expandable bag, located in the left of abdomen just beneath the diaphragm. The stomach has three regions: **cardiac**, just after the oesophagus, **fundus**, the largest part of stomach and **pyloric**, part located at the other end of stomach and opens into small intestine

The stomach muscles churn and mix the food with acids and enzymes, breaking it into much smaller, digestible pieces. An acidic environment is needed for the digestion that takes place in the stomach. Glands in the stomach lining produce about 3 quarts (2.8 liters) of these digestive juices each day. When food enters into the stomach the gastric juice is secreted by gastric glands found in the stomach wall. It is composed of mucous, hydrochloric acid and protein digesting enzyme pepsinogen. Hydrochloric acid converts the inactive enzyme pepsinogen into active form called pepsin. HCI also kills micro-organisms present in food. Stomach is protected against the action of acid by mucus.

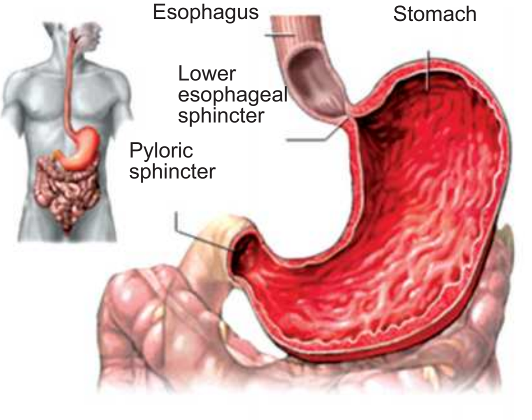


Figure 8.18 Stomach

Stomach has two sphincters (opening which are guarded by muscles). The cardiac sphincter is between stomach and oesophagus. Pyloric sphincter is between stomach and small intestine.

Pepsin partially digests the protein portion of the food into polypeptides and shorter peptide chains. In stomach food is further broken apart through a process called churning. The walls of stomach contract and relax and these movements help in mixing of the gastric juice and food. The churning action also produces heat which helps to melt the lipid contents of the food. By the time food is ready to leave the stomach, it has been processed into a thick paste like liquid called chyme. The pylorus keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then squirted down into the small intestine, where digestion of food continues.

Functions of small intestine:

The small intestine is made up of three parts:

- The duodenum, about 25 cm (10 inches) long, C-shaped first part.
- The jejunum, the coiled mid section.
- The ileum, the final section that leads into the large intestine.

The duodenum receives chyme from the stomach and it is a part of alimentary canal where most of the digestive process occurs. Ducts that empty into the duodenum deliver pancreatic juice and bile from the pancreas and liver, respectively.

Bile salts have detergent action on particles of dietary fat which causes fat globules to break down or be emulsified into minute, microscopic droplets.

Pancreatic juice is a liquid secreted by the pancreas, which contains a variety of enzymes, including protease like trypsinogen, pancreatic lipase and amylase, which digest protein, lipids and carbohydrates respectively.

Intestinal juices produced from the small intestine contain enzymes and pancreatic juice break down all four groups of molecules found in food (polysaccharides, proteins, fats, and nucleic acids) into their component molecules.

The inner wall of the small intestine is covered with millions of microscopic, finger-like projections called villi (singular, villus). Each villus is connected and richly supplied with blood capillaries and lymphatic vessels, i.e lacteal. The walls of villus are made up of only one layer of cells, in thickness. The villi are the vehicles through which nutrients can be absorbed into the body. They increase the surface area over which absorption and digestion occur. These specialized cells help absorbed materials cross the intestinal lining into the bloodstream. The bloodstream carries simple sugars, amino acids and nucleosides to the liver via hepatic portal vein for storage or further chemical changes. From liver, the required food molecules go towards the heart via the hepatic vein. The lymphatic system, a network of vessels that carry white blood cells and a fluid called lymph throughout the body, absorbs glycerol, fatty acids and vitamins.

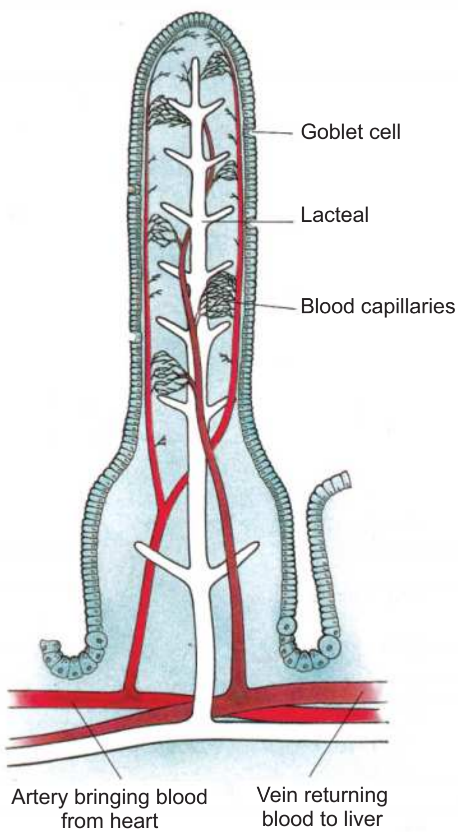


Figure 8.19 Longitudinal section through a villus

Macromolecules Summary

Polymers	Monomers	Roles
Complex Carbohydrates (i.e. starch)	Glucose and other simple sugars	Broken apart to get energy to make ATP.
Proteins	Amino acids	Used to make our own enzymes and other body proteins.
Lipids (Fats, waxes, oils, and steroids)	Fatty acid chains, glycerine (except steroids)	Used for cellular energy and energy storage; used to make cell membranes, steroid hormones.

Large intestine and its functions:

From the small intestine, food that has not been digested (and some water) travels to the large intestine through a muscular ring, that prevents food from returning to the small intestine. By the time food reaches the large intestine, the work of absorbing nutrients is nearly finished. The large intestine's main function is to remove water from the undigested matter and form solid waste that can be egested.

The large intestine is made up of three parts:

- The **caecum** is a pouch at the beginning of the large intestine that joins the small intestine to the large intestine. This transition area expands in diameter, allowing food to travel from the small intestine to the large. The appendix, a small, hollow, finger-like pouch, hangs at the end of the cecum. It no longer appears to be useful to the digestive process.

There's a lot of energy in cellulose, but most animals are simply unable to digest it because they don't have the necessary enzymes.

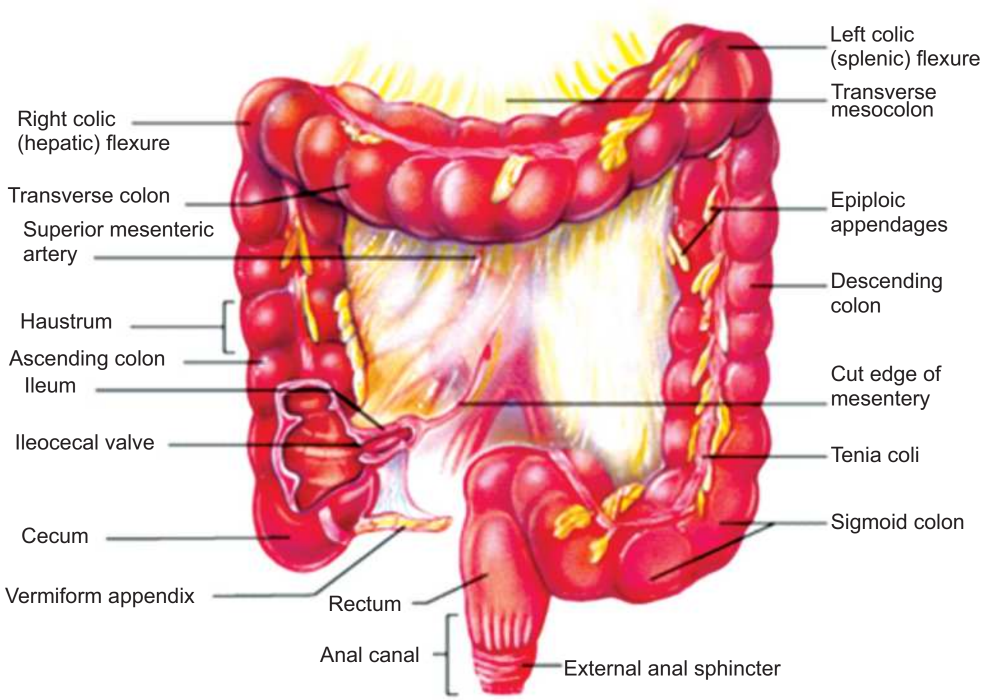


Figure 8.20 Large intestine

- The **colon** extends from the caecum up the right side of the abdomen, across the upper abdomen, and then down the left side of the abdomen, finally connecting to the rectum. The colon has three parts: the ascending colon and transverse colon, which absorb fluids and salts, and the descending colon, which holds the resulting waste (faeces). Faeces mainly consist of undigested material, large number of bacteria, sloughed off gastrointestinal cells, bile pigments and water. Bacteria in the colon help to digest the remaining food products.
- The rectum is where faeces are stored until they leave the digestive system through the anus as a bowel movement.

Liver and its functions:

The liver produces bile, which helps the body to digest and absorb fat. Bile is stored in the gallbladder until it is needed. Bile travels through special channel (bile duct) directly into the small intestine.

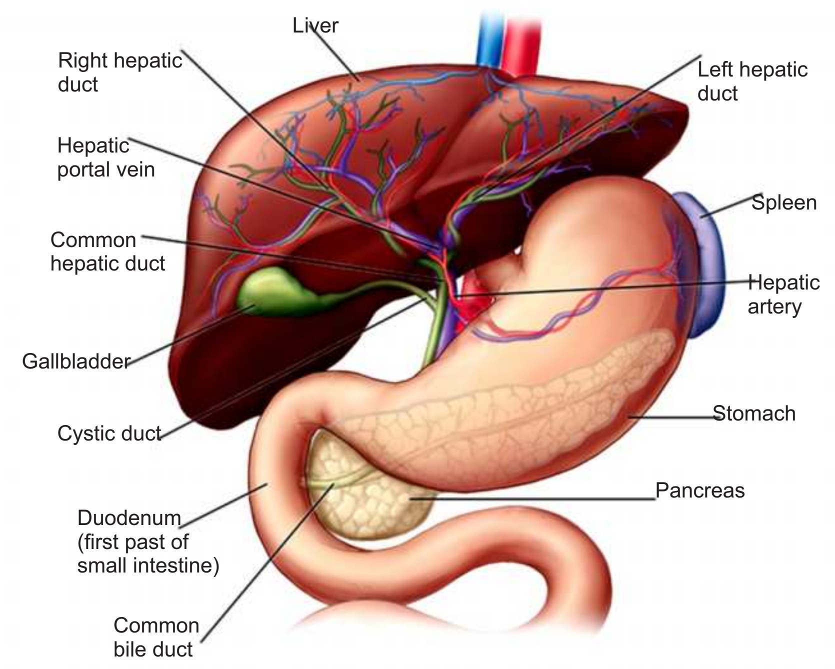


Figure 8.21 The human liver

It also makes a substance that neutralizes stomach acid. The liver also plays a major role in the handling and processing of nutrients, which are carried to the liver in the blood from the small intestine.

The liver is a metabolically active organ responsible for many vital life functions.

8.4 DISORDERS OF GUT

1. Diarrhea:

It is a condition in which the sufferer has frequent watery, loose bowel movements due to fast peristaltic movement. This condition may be accompanied by painful abdominal cramps, nausea, fever and generalized weakness. It occurs when required water is not absorbed in blood from colon. The main cause of diarrhea includes lack of adequate safe water, virus and bacteria. In malnourished individuals, diarrhoea leads to severe dehydration and can be life threatening. To control diarrhea consume adequate amounts of water to replace loss, preferably mixed with essential salts and some amount of nutrients.

2. Constipation:

Constipation is a condition, where a person experiences hard faeces that are difficult to eliminate. The main causes of constipation are hardening of faeces due to excessive absorption of water through colon, insufficient intake of dietary fibre, dehydration, use of medicine (e.g. those containing iron, calcium and aluminum) and tumors in rectum or anus. The treatment of constipation are change in diet and exercise habits, use of laxative (e.g. paraffin) may be in some cases. To prevent Constipation is easier than treatment.

3. Ulcer (peptic ulcer):

It is a sore in gut lining and can be different organs such as; ulcer of stomach is called “gastric ulcer”, Ulcer of duodenum is called “duodenal ulcer”, ulcer of oesophagus is called “esophageal ulcer” and breakdown of tissues by acidic gastric juice. It can be due to the long term use of anti-inflammatory medicine (e.g. aspirin), smoking, drinking coffee, colas and eating spicy food. Few of the signs are as under; abdominal burning after

meals, abdominal pain, rush of saliva after an episode of regurgitation, nausea and loss of appetite and weight. Ulcer can be treated with medicine, containing (alkaline composition) and avoiding spicy food.

Summary

- Process by which organism obtain and use the nutrients required for maintaining life is called nutrition.
- Autotrophic nutrition and heterotrophic nutrition
- Autotrophic nutrition found in plants and some bacteria specially photosynthesis.
- Heterotrophic nutrition found in animal and fungi which gets nutrients from other sources.
- Heterotrophic which use plant as food called herbivorous and those which consume animals. and their products called carnivorous. Both are collectively called consumers.
- The basis of mode living and the mode of intake of food heterotrophes may be parasitic, saprotrophic and holozoic.
- Nutrition in unicellular organisms, like amoeba involve igestion by cell surface.
- Process involving the absorption, distribution and utilization of mineral substances by plant called mineral nutrition.
- The mineral nutrients are macronutrient i.e require in large quantity, micronutrient i.e require in small quantity.
- Fertilizers are substances containing chemical elements such as manure or mixture of nitrates that improve growth of plants.
- Naturally occurring materials which are not chemically modified called inorganic fertilizer.
- Chemical substances which are more complex and takes time to be broken down into useable form called organic fertilizer.

- So many environmental hazard are also related to chemical fertilizers
- There are seven major classes of nutrients, Carbohydrates, proteins, fats, minerals, fibers, vitamins and water.
- Balanced diet is related to age, six and activity of human.
- Problems related to nutrition are grouped as malnutrition.
- Kwashiorkor is a severe difficulty in dietary protein.
- Marasmus characterized by energy deficiency sum of mineral difficulty diseases are Goiter, anemia.
- Effects of malnutrition are starvation, heart diseases, constipation, obesity.
- Digestion is the break down of complex food into simple absorbable nutrients.

Review Questions

1. Encircle the correct answer:

(i) Select the mismatched

(a) Protein → Amino acid
(b) Carbohydrate → Glucose
(c) Fats → Starch
(d) Nucleic acid → Nucleotide

(ii) Deficiency of vitamin-k cause

(a) Rickets
(b) Anemia
(c) Scurvy
(d) Beriberi

(iii) Period of rapid growth and development called

(a) Childhood
(b) Adult hood
(c) Adolescence
(d) Both “a” and “b”

(iv) Deficiency of dietary protein, causes an imbalance in the gastro-intestinal system

(a) Marasmus
(b) Edema
(c) Diarrhea
(d) Kwashiorkor

(v) An animal that migrates great distances would obtain the greatest benefit from storing its energy as

(a) Fats (b) Carbohydrates

(c) Protein (d) Minerals.

(vi) Which of the following vitamins is correctly associated with its use?

(a) Vitamin K → Production of white blood cells

(b) Vitamin C → Curing rickets

(c) Vitamin E → Protection of skin from cancer

(d) Vitamin A → Incorporated into the visual pigment of the eye

(vii) Which of the following statements describes pepsin?

(a) It is manufactured by the pancreas.

b) It helps stabilize fat-water emulsions.

(c) It splits maltose into monosaccharides.

(d) It begins the hydrolysis of proteins in the stomach.

(viii) Which of the following is true of bile salts?

(a) They are enzymes

(b) They are manufactured by the pancreas

(c) They emulsify fats in the duodenum

(d) They increase the efficiency of pepsin action.

(ix) In human digestive system trachea and oesophagus both connect to the

(a) Large intestine (b) Stomach

(c) Pharynx (d) Rectum

(x) All are sources of calcium except

(a) Red meat (b) Green leafy vegetables

(c) Broccoli (d) Nuts

2. Fill in the blanks:

(i) Sea food is an excellent source of protein because it's usually low in______.

(ii) Iron deficiency is associated with decreased cognitive abilities and resistance to_________.

(iii) Wave of rhythmic movements of muscle contraction and relaxation called______.

(iv) Liquid secreted by the pancreas, which contains a variety of __________.

(v) Living organisms which derive their food from dead and decaying organic materials called______.

(vi) Nutrients that are needed in the highest concentration called______.

(vii) Fertilizers are substances containing chemical elements such as manure or mixture of _________.

(viii) High solubility of fertilizers also degrades ecosystem through____________.

(ix) Carbohydrates which digested quickly are called _________.

(x) Each gram fat supplies the body with about_______.

3. Define the following terms

(i) Vitamins	(ii) Malnutrition	(iii) Goiter
(iv) Anemia	(v) Constipation	(vi) Obesity
(vii) Starvation	(viii) Ingestion	(ix) Chyme
(x) Ulcer		

4. Distinguish between the following in tabulated form.

(i) Fat-soluble vitamins and water soluble vitamins

(ii) Marasmus and kwashiorkor

(iii) Chemical digestion and mechanical digestion

(iv) Autotrophic nutrition and heterotrophic nutrition

(v) Inorganic fertilizers and organic fertilizers

5. Write short answers of following questions.

(i) Why fertilizers are necessary for plant?

(ii) How stomach linings are protected from acidic environment?

(iii) Why nitrogen is essential for plants?

(iv) Why fats are called most efficient form of food?

(v) Why grinding and lubrication are necessary for swallowing?

6. Write detailed answers of the following questions.

(i) Describe environmental hazards related to chemical fertilizers.

(ii) Describe function of stomach and intestine with suitable diagram of human digestive system.

(iii) What are vitamins? Describe types of vitamins

(iv) Describe mineral deficiency diseases in human.

(v) Describe effects of malnutrition on human.

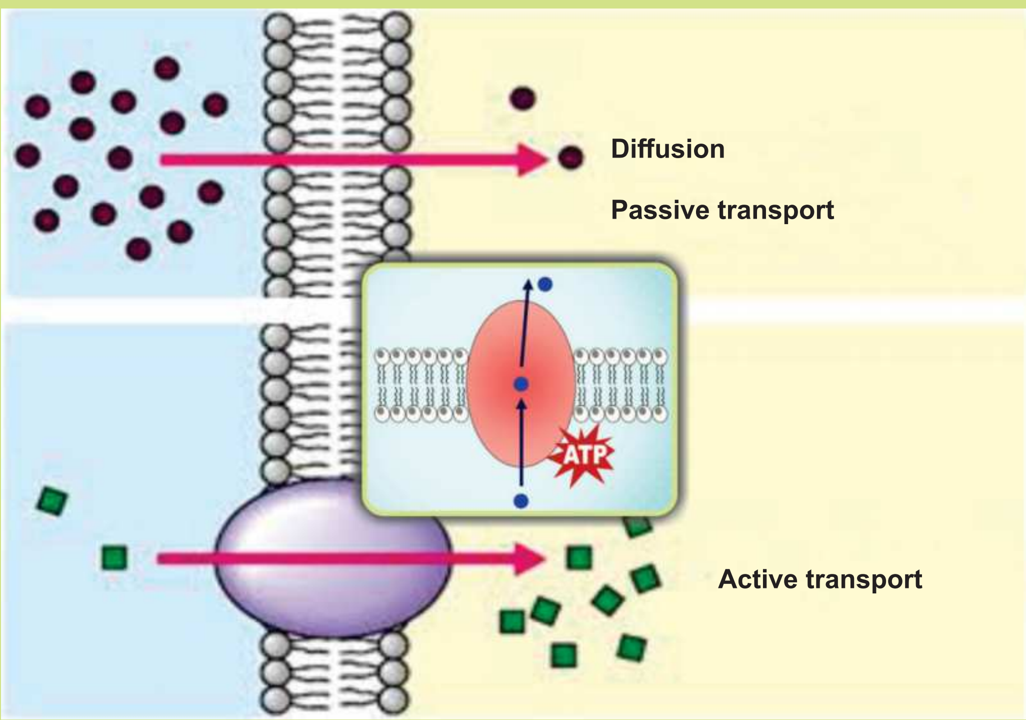
TRANSPORT

Chapter 9

Major Concept

In this Unit you will learn:

- Introduction
- Transport in Plants
  - Water and ion uptake (Structure and function of root hairs)
- Transpiration
  - Introduction and Significance
  - Factors affecting the rate of transpiration
- Transportation of Food and Water
  - Pathway of water and food in stem
  - Structure and function of Xylem and Phloem
- Transport in Animals
- Transport in Man
  - Blood
  - Components of Blood and their Functions
  - Disorders of Blood (Leukemia and Thalassemia)
  - Blood Groups and Blood Transfusion
- Human heart
  - Blood Vessels



Every organism requires number of substances for their survival and maintenance of healthy life. These substances or their raw materials are taken by organism from environment or may be from internal sources. If the distance between source and required organ is small enough, organism does not require any transport system but if the distance is too long then the organism require to develop a system called **transport system**. The transport system requires atleast two component.

(i) Transport of raw material from environment to organ where they required for metabolism.

(ii) Transport of metabolites from cell to organs where they require.

Plants are autotrophs which synthesize organic biomolecules from inorganic molecules. These inorganic molecules are transported from environment into plants, converted into biomolecules. These biomolecules are also transported within the plant where they required.

Animals are heterotrophs which get organic molecules as food, digest them into digestive tract, diffuse into blood and transport to organs where required.

9.1 TRANSPORT IN PLANTS

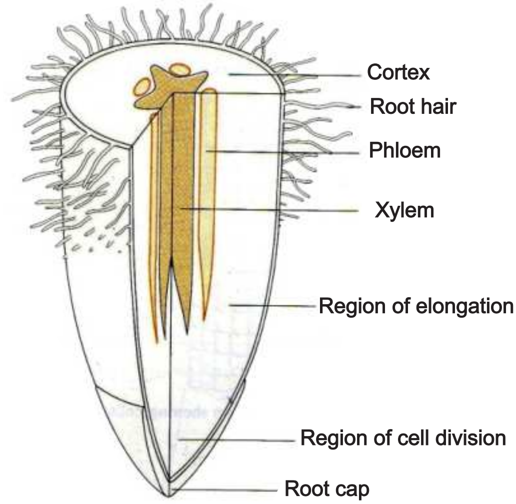
Root as important organ for water and Mineral transport:

Water and mineral salts enter the plant through root, so it is necessary to understand the external and internal structure of root. Externally, root has a root tip which is the growing part of root covered by root cap. The remaining part of root is highly branched and each branch is heavily covered by root hairs. Each root hair is a fine tubular outgrowth of an epidermal cell. It grows between soil particles which remains in close contact with the soil solution surrounding them.

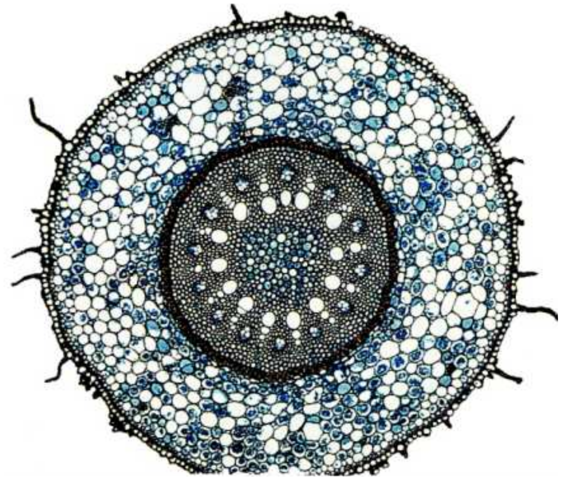
Internally, we can study the root by taking transverse section (T.S.) of root. The T.S. of root shows that root is mainly consist of:

- **Epidermis** (Epiblema) the outer layer of cells, some of these cells have root hair.

- The **Cortex** part of root between epidermis and endodermis, consist of number of cellular layers.



Root structure



Transverse section of root

Fig: 9.1 Root structure with transverse section of root

9.1.1 Water and ions uptake:

The root absorb water and minerals from soil through root hairs. There are two processes of transport:

(a) **Passive transport:** The uptake of water and mineral by osmosis and diffusion without using energy of ATP. It is due to concentration gradient i.e. always takes place from high to low quantity of substances.

(b) **Active transport:** Movement of substances from low quantity to high quantity i.e. against the gradient and it requires energy of ATP. This movement is called active transport.

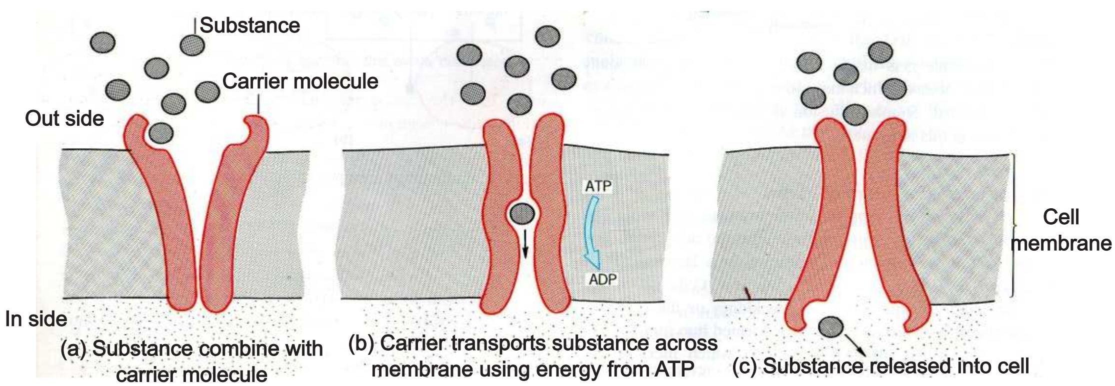
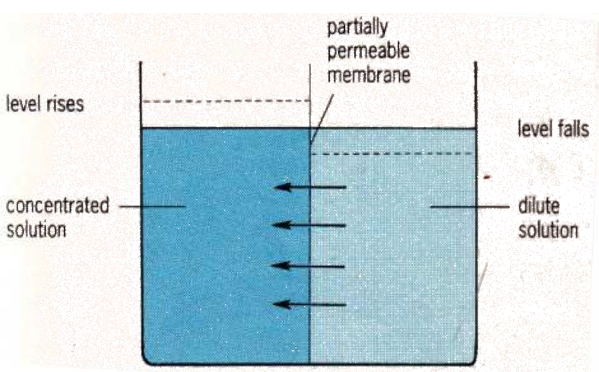


Fig: 9.2 Active transport

1. Uptake of Water From Soil:

The root hair is long, thin and tubular structure. It increases the surface area which increases the rate of absorption of water and minerals. The cell membrane prevents the cell sap (a mixture of sugar, salts and amino acids in solution form) from leaking out. The cell sap has low tendency of water loss i.e water potential, than the solution of soil which result in water movement from soil to root hair. This process of water movement from a solution of high water potential to a solution of low water potential is called **Osmosis**. As a result of osmosis of water, the root hair become turgid and their cell-sap become dilute than that of adjacent cells so the water moves from root hair to their neighbour cells. In this way, water may pass from cell to cell and finally forced into xylem and ascend up to the aerial part of plant. This upward movement of water with mineral is called ascent of sap, other factor and forces are also involved in ascent of sap.

For absorption of water by root, it is necessary that the solute quantity in soil solution should be low and solute quantity in sap should be comparatively high, otherwise the direction of water movement will be reversed and plant may die due to dehydration.



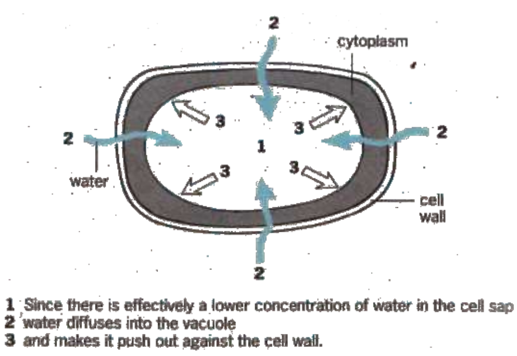


Fig: 9.3 Diagram showing process of Osmosis and Diffusion

2. Mineral transport:

Plant also require minerals i.e nitrates, sulphates, phosphates etc. These minerals are also taken up by root hair in two ways:

(a) By diffusion, when the concentration of certain ions in soil is higher than that in root hair cells i.e passive transport.

(b) By active transport, plant requires some substance even they found in soil in low quantity. The roots have to absorb these ions against a concentration gradient by using energy of ATP, which is active transport.

9.2 TRANSPIRATION

Plants absorb water continuously from soil. Some of its quantity utilized in photosynthesis and other metabolic functions while the rest is retained in cell to maintain turgidity of cell. Some water is removed in the form of vapours. This loss of internal water of plant in the form of vapours from aerial part of plant is called **transpiration**. Transpiration mainly takes place through special pores guarded by specialized guard cells called **stomata** (sing: stoma).

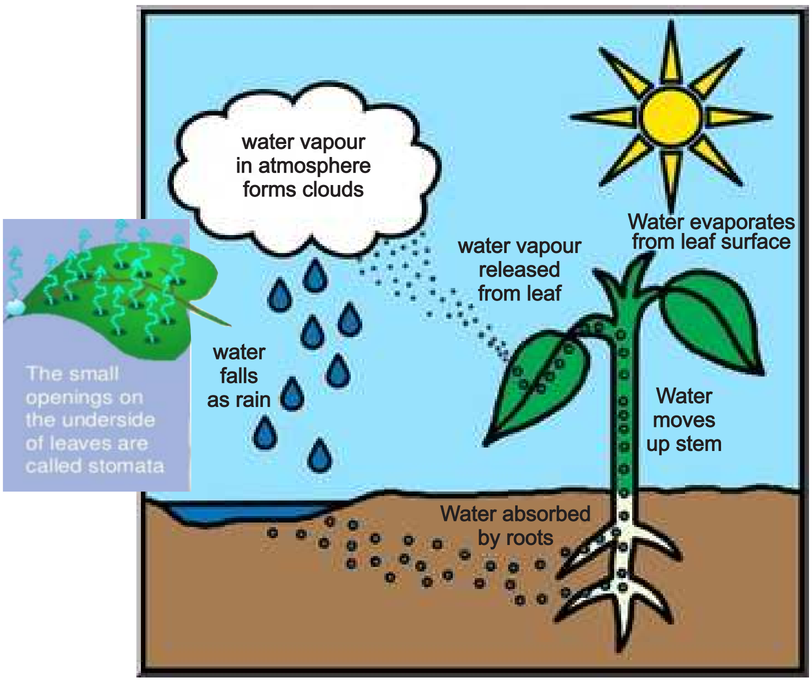


Fig: 9.4 Transpiration — showing loss of water vapours from stomata

Evidences of transpiration:

- Take a potted plant and wrap a polythelene bag around pot not around the plant to make sure that water is not coming from soil of pot and surface of pot.

- Place the pot on the glass plate and cover it with dry bell jar.
- Take another jar without plant for control setup.
- Put these two jars side by side in an area where light fall on it for two hours.

Observation:

You will observe water droplets at the bell jar which has plant while other jar remains dry.

9.2.1 Relation of transpiration with leaf surface:

Plants have three types of leaves on the basis of stomatal distribution.

(i) Leaves that have stomata at lower epidermis called **bifacial leaves** e.g leaves of mango plant.

(ii) Leaves that have stomata at both surfaces (upper and lower epidermis) called **monofacial leaves** e.g leaves of maze plant.

(iii) Leaves that have stomata at upper epidermis only e.g leaves of water lily.

Activity: To find that transpiration mainly take place through stomata perform simple experiment.

Requirement:

Few leaves, petroleum jelly or wax, scale etc.

Procedure:

- Take three leaves of pepal or mango tree where stomata are mainly present at lower surface of leaves.
- The leaves should be of equal size.
- Treat leaves as follows:

  Leaf 1- cover the upper epidermis surface with petroleum jelly or any wax.

  Leaf 2- cover lower surface with same.

  Leaf 3- cover both surfaces with same.
- Weigh each leaf before and after covering.
- Hang these leaves near window in sunlight.
- After few hours note the conditions and weigh again.
- Leaf which loss more weight transpire effeciently.
- It will be observed that the leaf 1 transpire more effeciently because it has stomata at lower epidermis.

The experiment shows that most of the water vapour is lost from the surface where stomata are present.

Surface area of leaf is also an important factor for the rate of transpiration, because the larger size leaves have high number of stomata which increases the rate of transpiration. The desert plants require to save their water so they have smaller size leaves or their leaves become spines to reduce number of stomata as well as rate of transpiration.

9.2.2 Stomata and its opening/closing mechanism:

Stomata are the pores usually found in the leaf epidermis surrounded by two kidney shaped guard cells, these cells contain chloroplast while other epidermal cells do not. The guard cells control the opening and closing of stomata. The inner wall of guard cells is thick and inelastic whereas the outer wall is thin, elastic and permeable. The changes in the turgidity of guard cells controls the opening and closing of stomata. Stomata open when the guard cell become turgid and close when the guard cells become flacid. The turgidity of guard cell is regulated by concentration of solutes present in it which mainly depends upon the rate of photosynthesis. Opening and closing of stomata is one of the important factor to control rate of transpiration. The stomata remain open during the sunny day, as a result rate of transpiration increases. But at night they are closed, hence transpiration also stops.

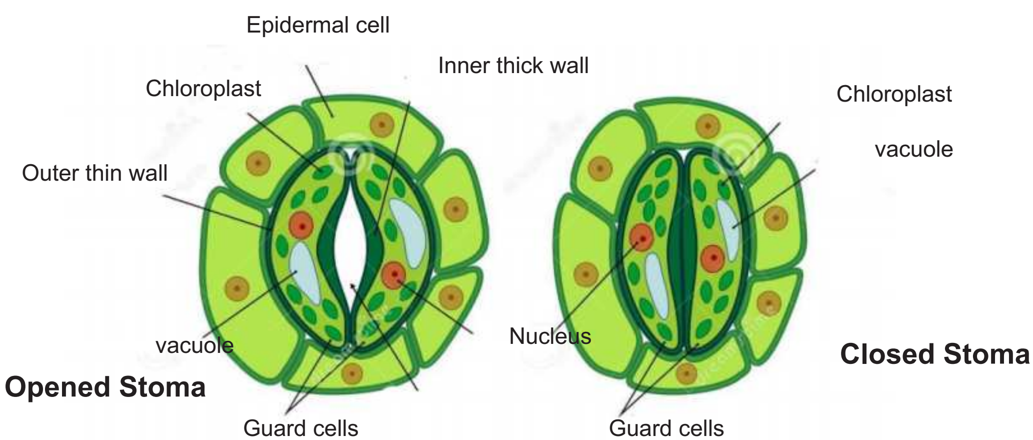


Fig: 9.5 Diagram showing opening and closing of stoma

9.2.3 Significance of transpiration:

Transpiration maintains low concentration of water and high concentration of solutes in cell i.e. high solute potential. The high solute potential of leaf cells attract more water and draw more water from xylem. This continuous withdrawl of water from xylem develops deficit of water in xylem which develops a pull or tension called transpiration pull. As a result of this transpiration pull and water attraction for other water molecule i.e cohesion of water, water is pulled upward in the xylem vessels through a continuous column called transpiration stream, which helps in ascent of sap.

- By active transpiration, transpiration pull is created which helps in the ascent of sap.
- Transpiration also increases the rate of absorption because the loss at one end increases demand on other end.
- Transpiration gets rid of the excess amount of water from plant.
- Transpiration helps in mantaining the temperature of plant for its metabolism and survival because evaporation causes cooling.
- Opening and closing of stomata is also regulated by transpiration, which indirectly influences upon the rate of photosynthesis and respiration.

Every year number of plants die in hot summer day due to excessive loss of water from aerial parts which results in wilting and dehydration and ultimately may lead to death of plant in extreme conditions.

Transpiration is considered as necessary element for plant due to its advantages which are discussed above but on the other hand, it is also considered as an evil for plant because million of plants die every year due to excessive transpiration.

9.2.4 Factors affecting the rate of transpiration:

The rate of transpiration is also affected by some of the following environmental factors.

(i) **Temperature:** Rate of evaporation of water from cell surface increases with increase in temperature.

(ii) **Humidity:** Transpiration takes place only when concentration of the vapours must be low outside than inside, so dry atmosphere is also the condition for transpiration.

The rate of transpiration decrease with the increase in water vapours in atmosphere i.e. humidity.

(iii) **Wind:** The increase in wind velocity increases the rate of transpiration. The wind decreases the water vapours around plant and make the atmosphere dry.

(iv) **Atmospheric Pressure:** Low atmospheric pressure increases the rate of transpiration through reduction in the density of air.

9.3 TRANSPORT OF WATER AND FOOD IN STEM

Flowering plants have a system of vessels for transport of water, minerals and food. These vessels are called transport or vascular tissues. There are two types of transport tissues in plants.

Xylem (Wood):

In flowering plants xylem is made up of four type of tissues but the main tissues are the xylem vessels. A xylem vessel is a long, hollow, tubular structure from root to leaf. It is made up of many dead cells arranged vertically. The walls of these vessels become strong by the deposition of chemical substance called lignin.

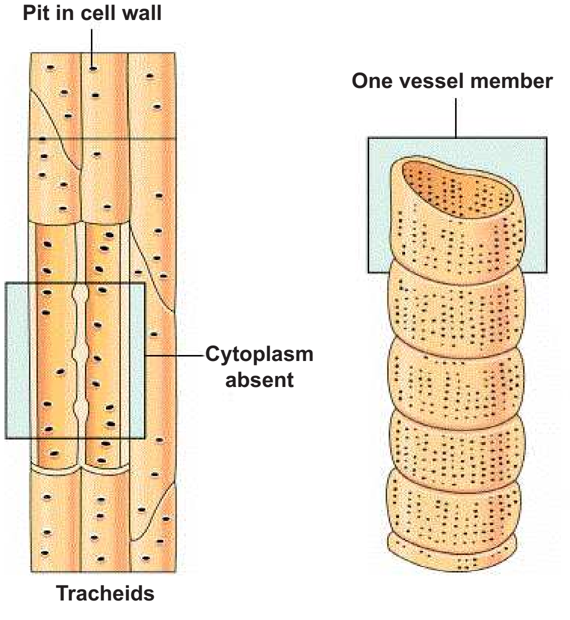


Fig: 9.6 Xylem conducts water and dissolved minerals

9.3.1 Water and mineral transportation:

Dead cells of xylem vessels arranged vertically have empty space inside called lumen, without protoplasm and end walls. This tube reduces the resistance of water flowing through the xylem. It gives faster passage to sap, as a result transpiration pull is created in leaf. The thick, rigid and lignified walls of vessels also provides mechanical support which strengthen the wall.

Phloem (Bast):

Like xylem, phloem is also made up of four type of tissues but mainly consist of sieve tubes and companion cells. Phloem conducts manufactured food (sucrose) from part of plant where it is synthesized in high quantity to other parts of plant where it is required.

The sieve tubes or sieve tube elements of phloem is made up of columns of elongated and thin walled living cells. The transverse walls separating the cells have lots of minute pores. The cross walls look like a sieve and therefore called **sieve plates.**

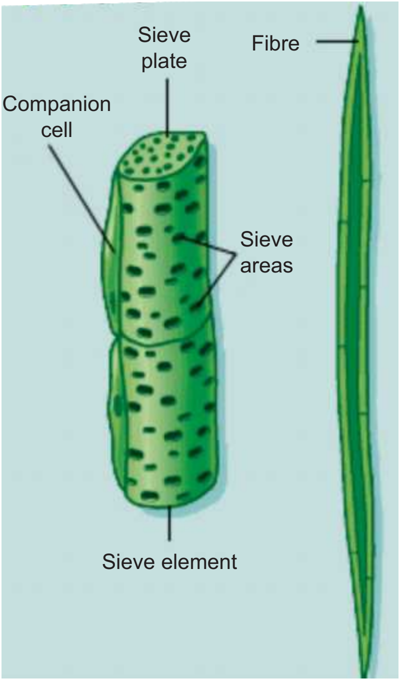


Fig: 9.7 (a) Phloem and its component

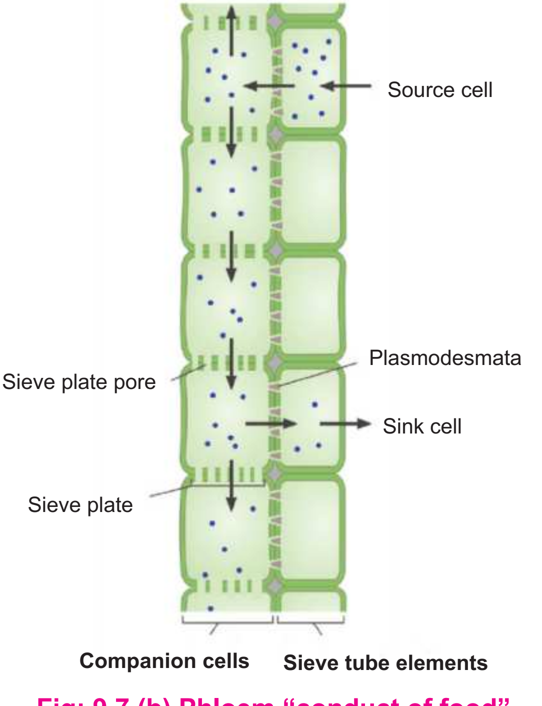


Fig: 9.7 (b) Phloem "conduct of food"

A mature sieve tube cell has only a thin layer of cytoplasm inside the cell. This cytoplasm is connected to cells above and below through sieve plates. Each sieve tube cell has lost its central vacuole, nucleus and most organelles. Each sieve tube cell has a companion cell beside it, which carries out the metabolic processes need to keep the sieve tube cells alive. Each companion cell is a narrow, thin walled cell with many mitochondria, cytoplasm and a nucleus. Companion cells provide nutrients and help the sieve tube cells to transport manufactured food.

Conduction of food by phloem:

In contrast to sieve tube cell, the companion cells have many mitochondria to provide energy needed for the companion cells to load sugar from mesophyll cell to sieve tube cells by active transport. The perforations of sieve plates allow rapid flow of manufactured food substance through the sieve tube.

9.3.2 Transport of organic materials (food) in plants:

In higher plant, only the green parts specially leaves can manufacture food and it must be supplied to other non green parts like root, stem and flower for consumption and storage.

The movement of organic materials (food) take place through phloem. Along with food, phloem also conducts other substances such as vitamins, hormones etc. The movement of prepared food from leaves to different parts of plant through phloem elements (sieve-tubes) is called translocation.

It is an established fact that translocation of solutes take place through phloem but it is still debatable that how it occurs. Several hypothesis and theories have been proposed to explain the mechanism of translocation. Among them bulk-flow or Munch hypothesis is the most convincing.

According to this hypothesis, solutes are translocated through the sieve tubes which flow in bulk from the supply end i.e source (leaves) to the consumption end i.e sink (root) under a turgor pressure gradient.

As a result of photosynthesis, the supply ends (leaves) have a large amount of organic solutes, which causes tremendous increase in suction

pressure of leaf cells (Mesophyll cells) and they draw water from the xylem of the leaf. As a consequence their turgor pressure is increased. The turgor pressure in the cells of stem and root is comparatively low and hence, the soluble organic solutes begin to flow in mass from mesophyll through sieve-tubes down to the cells of stem and root under the gradient of turgor pressure. These solutes are either consumed or stored in insoluble form. The excess water is released back into the xylem vessels.

9.4 TRANSPORT IN ANIMALS

cytoplasm of unicellular animals remains very much close to plasma membrane which remains in contact with environment. In these animals oxygen can diffuse through the body surface and reach easily to energy producing organelles. Similarly, the waste products can rapidly move from the body by simple diffusion.

On the other hand, in multi-cellular organisms like mammals including man, many cells are situated away from environment. Only simple diffusion is not enough to supply O_2 (oxygen) to these cells and to get rid of wastes from there. It needs proper transport system to carry substances from one part of the body to another. The system involved in the transport of various substances within the body of an animal is called Circulatory System. The circulatory system transports gases like O_2, CO_2 etc, nutrients, wastes, hormones and defense proteins.

There are two types of Blood Circulatory Systems found in animals

(i) Open circulatory system

(ii) Closed circulatory system

(i) Open circulatory system:

In this type of Circulatory System blood flows through the spaces among tissue so it directly comes in contact with tissues. It remains filled in the open tissue spaces called Sinuses.

After exchange of materials with tissues, blood enters the pumping organs or heart which pumps it into blood vessels.

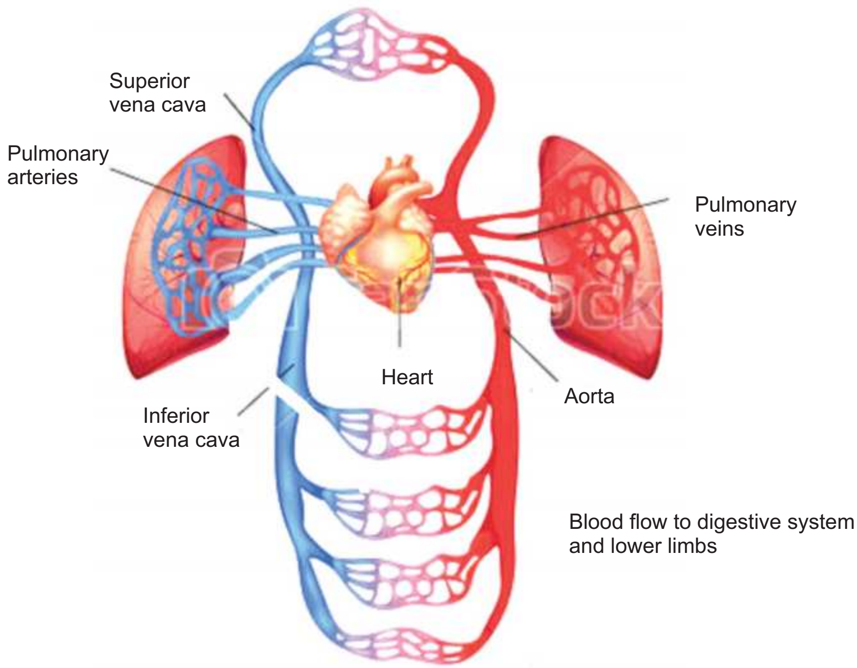


Fig: 9.8 Blood flow to head and arms

These vessels again drain out blood into sinuses so it remains in Circulation. This type of circulatory system found in arthropods and molluscs.

(ii) Closed circulatory system:

This type of system allows blood to flow inside the closed tubular blood vessels and never comes out in direct contact with tissues.

9.5 TRANSPORT IN MAN

In man, closed type of circulatory system is found, which consists of following components.

(i) Blood: A fluid with cells and other dissolved substances.

(ii) Heart: A pumping, pulsatile organ.

(iii) Blood vessels: Tubes i.e. Arteries, veins and capillaries.

This is much more efficient and rapid system of transport.

9.5.1 Blood:

Blood is a special type of tissue, found in the form of fluid which circulates in the body. It transports substances in the body of an organism. It consists of two parts:

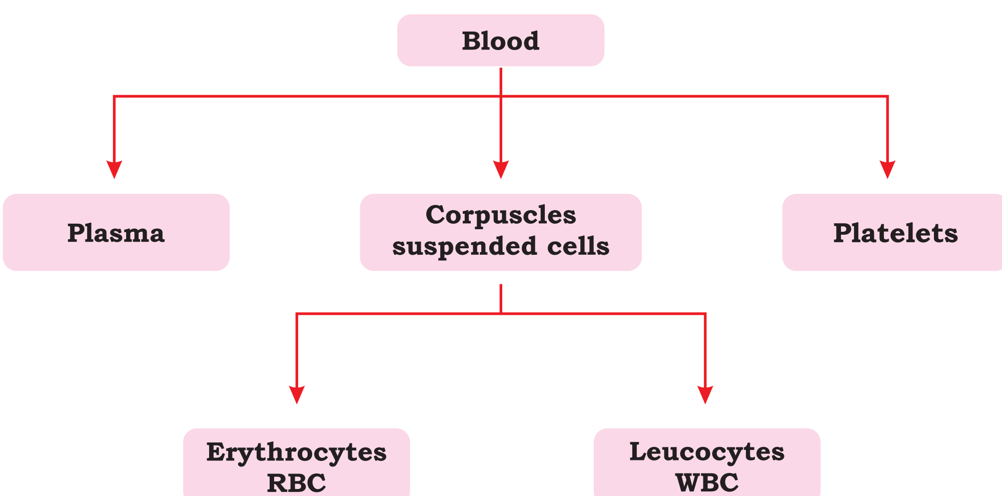
(i) Plasma (ii) Corpuscles

(i) Plasma:

Plasma is the fluid part of blood and constitutes about 55% by volume of whole blood. It is pale yellowish liquid. About 90% of plasma is water in which complex mixture of various substances are dissolved. There are dissolved mineral salts like bicarbonates, sulphates, chlorides and phosphates of sodium (Na) and potassium (K). All these are found in the form of ions. Salts of calcium are also present in blood for clotting of blood.

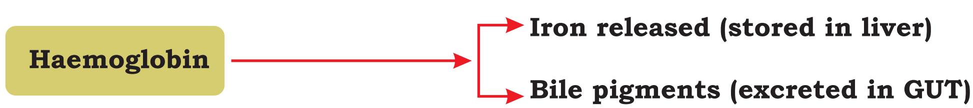
Soluble proteins are also present in plasma i.e. Serum albumin, Serum globulin, fibrinogen and prothrombin. The last two play important part in clotting of blood. Antibodies are also present in plasma, which are involved in fighting diseases.

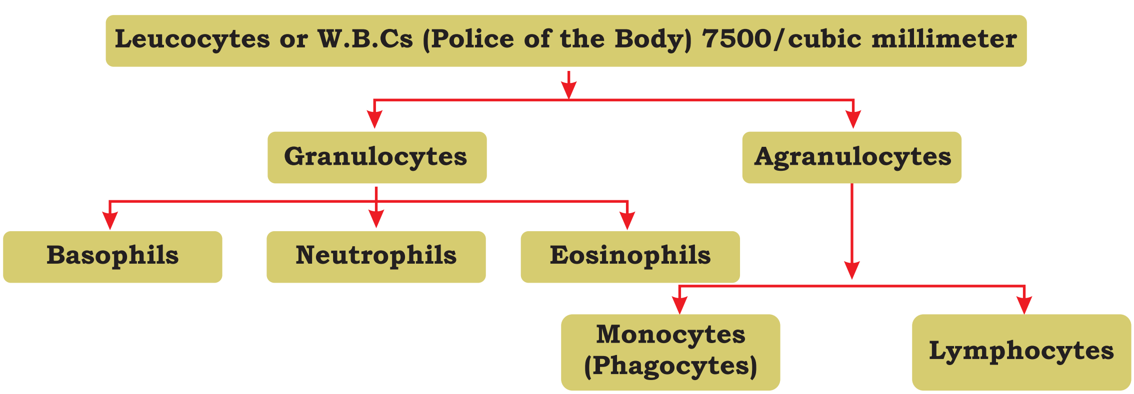
Plasma contains digested food substances such as glucose, amino acids, fatty acids and vitamins. It also contains excretory products such as Urea, Uric acid and creatinine. Carbondioxide (CO_2) is also present as bicarbonate ions. It also contains hormones.



Erythrocytes (R.B.Cs)	
SHAPE	Bi-concave; Circular like disc
SIZE	0.007-0.008 mm in diameter
COMPOSITION	Non-nucleated, contain red pigment haemoglobin protein containing iron.
QUANTITY	5,000,000/cubic millimeter
PLACE OF PRODUCTION	Bone marrow
LIFE	120 days on Average
PLACE OF DESTRUCTION	Spleen and liver
FUNCTION	Transports O_2 from lungs to body cell Transports CO_2 from body cell to lungs

Break down of Haemoglobin





Leucocytes or WBCs are colourless, irregular in shape, nucleated and lager sized cell than R.B.Cs. They protect the body by killing germs that enter the body. There are several types of White blood cells which perform different functions.

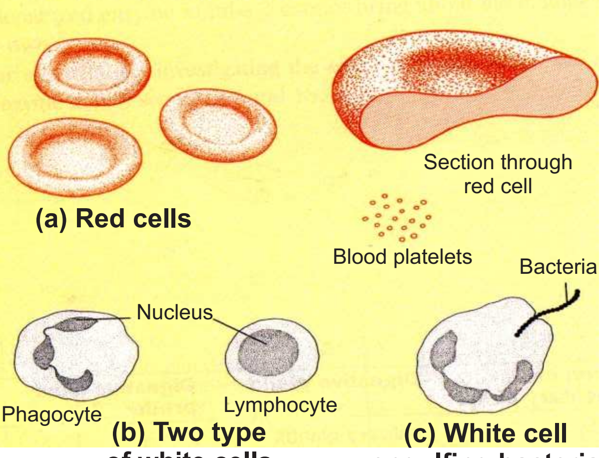


Fig: 9.9 Blood cells

Types of WBCs	Description	Average number	Function
(A) Granulocytes			
Neutrophils	About twice the size of RBCs, nucleus 2 to 5 lobed	62% of W.B.Cs	Destroys small particles by Phagocytosis
Eosinophils	Nucleus bilobed	2% of W.B.Cs	Inactivates inflammation producing substances, attack parasite
Basophils	Nucleus bilobed	Less than 1% of W.B.Cs	Release heparin to prevent blood clots and histamine which causes inflammation
(B) Agranulocytes			
Monocytes	3 to 4 times larger than RBCs, nuclear shape from round to lobed	3% of W.B.Cs	Macrophages, destroys large particles by phagocytosis
Lymphocytes	Slightly larger than RBCs, nucleus nearly occupies cell	32% of W.B.Cs	Immune response by producing antibodies

(ii) Platelets:

Platelets are the fragments of cells which are formed from large precursor cells in the bone marrow. On injury, exposure to the air stimulate the platelets at cut end to produce an enzyme in blood. This enzyme causes the soluble plasma protein fibrinogen to form insoluble fiber of another protein fibrin which forms a network of fibers around wound. It protects blood to flow, that is called clot, which prevents bleeding and stops the entry of pathogen.

Blood disorders:

(a) Leukemia:

It is a type of cancer that affects the blood, bone marrow and lymphatic system. In this type of blood cancer, number of W.B.Cs increases and R.B.Cs decreases.

Symptoms:

- Fever or chill
- Frequent or severe infections
- Swollen lymph node
- Easy bleeding or bruising
- Ting red spots on skin
- Bone pain or tenderness
- Persistent fatigue, weakness
- Loss of weight without try
- Enlarge liver or spleen
- Recurrent nose bleeding
- Sweating at night

Causes:

Leukemia is thought to occur when some blood cells acquire mutations in their DNA. Some abnormalities cause the cell to grow and divide more rapidly and continue living when normal cells would die. With passage of time, these abnormal cells in the bone marrow, leading to fewer healthy white blood cells, red blood cells and platelets.

- Genetic disorder
- Exposure to certain chemicals
- Smoking
- Family history

(b) Thalassemia:

It is the name of a group of inherited conditions that affect the blood haemoglobin. Persons having thalassemia do not produce or produce little amount of haemoglobin, which is used by red blood cells to carry oxygen around the body. Person having problems of thalassemia having following symptoms.

Symptoms:

- A pale and restless appearance
- Slowed growth and delayed puberty
- An enlarged spleen, liver or heart
- Poor appetite
- Dark urine
- Jaundice

Thalassemia major:

It occurs when a child inherits two mutated genes, one from each parent. Children born with this disorder usually develop the symptoms of severe anemia within the first year of life. They lack the ability to produce normal, haemoglobin and feel chronic fatigue.

Thalassemia minor have occurred when a child inherit it from one of the parent. Persons have mild anemia and slight lowering of haemoglobin level in the blood. It resembles with mild iron deficiency anemia. People with this disorder do not have any symptoms.

9.5.2 Heart:

Heart is the major organ of Circulatory system. It is a muscular pump which keeps the blood circulating through out the body. It is located in the thorax slightly at the left side. It is enclosed in a fibrous bag like protective cover called Pericardium. It is conical in shape externally. The space between pericardium and heart is pericardial cavity which is filled with a fluid called pericardial fluid. This fluid reduces friction and Pericardium protects the heart, prevent it from over extension.

Internally, it consists of four chambers, the upper two are thin walled called atria (sing: artrium) the lower two are thick walled called ventricles. Atria are completely separated from each other by a septum called inter-atrial septum. Similarly, the two ventricles are also separated from each other by a muscular partition called inter-ventricle septum. Each atrium is connected with its ventricle by an auriculo-ventricular aperture. The

right atrium and right ventricle are connected by Tricuspid Valve. Similarly, left atrium and left ventricle are connected by bicuspid valve. These valves prevent the backward flow of blood from the ventricles to the atria. Two main blood vessels are arising from ventricles to carry blood from heart to all parts of the body.

The blood from the right ventricle is pumped through pulmonary arch to the lungs for oxygenation while the blood from the left ventricle is pumped through a systemic aorta to all the parts of the body. The pulmonary arch and systemic aorta, both are guarded by semi-lunar valves to prevent backward flow of blood.

There is a difference in thickness of muscle wall of the left ventricle as compared to right ventricle.

The left ventricle is much thicker and narrow in space. This is related to their functions. The right ventricle only pumps blood to the lungs while the left ventricle pumps blood to all other parts of the body. The resistance to blood flow through the body capillary networks is for higher than that through the lung capillaries so, a high pressure is developed in the systemic circulation, it requires a thicker muscle wall and narrow space.

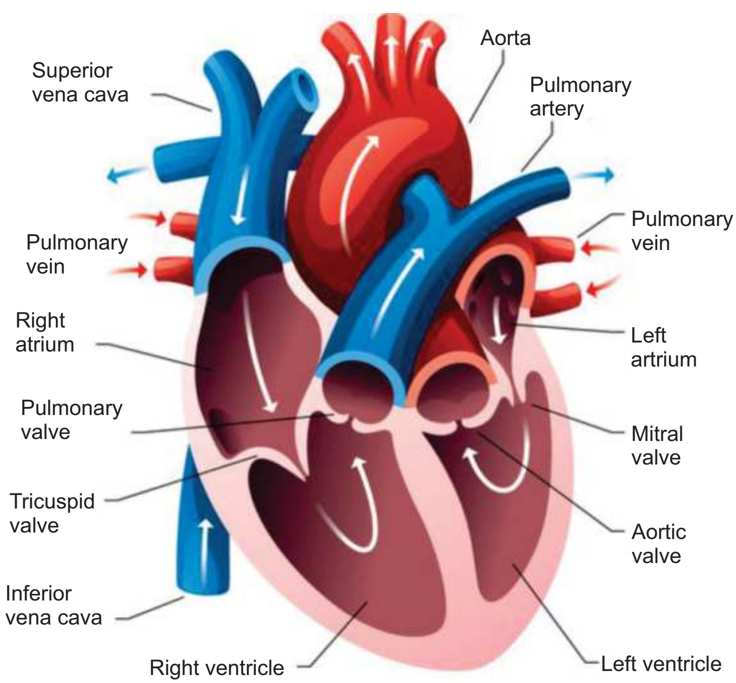


Fig 9.10: of Heart (internal and external L.S. of heart).

The function of atria is to stretch to receive blood as it returns to the heart and then contract with enough force to push the blood through the atrioventricular valves into the ventricles. This requires a lower pressure than that developed in the ventricles, so the walls of the atria are much thinner and more elastic than those of the ventricles.

The circulation of blood in our body is called double circuit system because it circulates blood in two separate circuits and enter twice in heart during complete circulation. These two circuits are:

1. **Pulmonary Circuit;** from heart to lungs and back from lungs to heart.
2. **Systemic Circuit;** from heart to different organs and from organs back to heart.

1. Pulmonary circuit:

It transports blood from right ventricle to lungs through pulmonary arteries and flow back to heart in left atrium through pulmonary veins.

The deoxygenated blood from all over the body except lungs received in right atrium and then collected into right ventricle, upon contraction of ventricle this deoxygenated blood enters into pulmonary arch which supply this blood to the lungs, where blood gives up its CO_2 and receives O_2 from air at capillary level. The deoxygenated blood now becomes oxygenated which flow back to the left atrium through pulmonary veins. This oxygenated blood now circulates through the body by Systemic Circulation.

2. Systemic circuit:

Circulation of oxygenated blood from left ventricle through systemic aorta to all organs of body and back to heart by superior and inferior vena cava as deoxygenated blood is called systemic circulation or circuit. Upon contraction the left ventricle forces oxygenated blood into systemic aorta, the largest artery of our body. Initially, the aorta gives off three branches which supply blood to head, arms and shoulders. This aorta then descends down and gives off many branches which supply blood to their respective organs e.g. a branch which supplies blood to liver called Hepatic artery, another branch called renal artery supplies blood to the kidney and coronary artery to heart etc.

Heart beat:

The pumping of blood by the rhythmic pulsation of heart throughout the body is called heartbeat. It is a two phase pumping action of blood that takes less than a second. When blood is collected in the left and right atria, the heart receives an electrical signal that causes the atria to contract. This contraction pushes blood into the right and left ventricles through tricuspid and bicuspid valves respectively.

The second phase of pumping blood begins when the ventricles are full of blood. The electrical signals travel along a pathway of cells to the ventricles, this causes ventricles to contract. The relaxation of heart muscle and allowing the chambers to fill with blood, this phase of heartbeat is called **diastole**. The contraction of heart muscle and pumping the blood from the chambers into the arteries named as **systole**.

Heart rate:

The number of heartbeats in a minute i.e. the heart rate can be measured by the beating of heart. On average, a healthy heart beats 72 times in a minute. The normal range of heart rate is 60 – 100 beats in a minute. It is necessary to keep the heart rate within the normal range. The slow or fast heart rate may cause severe heart diseases. The heart rate may vary from person to person. The decreasing heart rate is a result of slow heartbeat, which leads to a condition called bradycardia. In this condition, the heart rate is too slow (or below 60 beats per minute) due to very slow heartbeat. This slow heart rate reduces amount of blood and oxygen to vital organs of body, and causes shortness of breath, dropping of blood pressure, extreme fatigue etc.

On the other hand, when a heart beats very fast (more than 100 beats per minute), this condition is called tachycardia. Due to this rapid heart rate, the function of heart becomes very hard. It means that the heart does not have enough time to fill with blood and enough blood is pumped forward. The tachycardia is caused by the fever, dehydration, excessive caffeine or a reaction to medication. Chest pain, dizziness and fainting are the symptoms of tachycardia.

Causes of tachycardia can be:

- Sudden cardiac arrest
- Heart failure
- Weaken heart muscle
- Lung diseases

Pulse rate:

Contrary to the heart rate, the pulse rate is exactly equal to the heartbeat. If the heartbeat is faster so as the pulse rate and if the heartbeat is slower, the pulse rate will be slower too. Taking a pulse is therefore a direct measure of heart rate.

9.5.3 Blood vessels:

The way large buildings have the corridors, similarly blood vessels run through all of the tissues of body, while some blood vessels are as wide as your thumb, most of them are much finer than a human hair. There are three types of blood vessels, which are;

(i) Arteries, (ii) Veins and (iii) Capillaries.

(i) Arteries:

Blood vessels carry oxygenated blood (except pulmonary artery) away from the heart. Right ventricle of heart pumps blood into the pulmonary artery that goes to the lungs. Left ventricle of heart pumps blood into the aorta (largest artery in body). Every organ receives blood from arteries that branch off the aorta. The first branch called the coronary artery, carry blood to the walls of heart itself. Other branches carry blood to the brain, intestine and other organs.

Arteries wall consist of three layers, the inner most layer, which is made up of epithelial tissues. The middle layer consists mostly of smooth muscle and elastic fibers. The outer wall is made up of flexible connective tissue. Because of layered structure arteries have both strength and flexibility.

(ii) Veins:

Blood vessels carry deoxygenated blood (except pulmonary vein) from body towards the heart. The walls of veins, like those of arteries have three layers, with muscle in the middle layer. However, the walls of vein are generally thinner than those of arteries. They have large lumen.

Blood pressure in the veins is much lower than the blood pressure in the arteries. Semilunar valves in the veins prevent backflow of blood. Flow of blood along the veins is assisted by the action of skeletal muscles on the veins.

(iii) Capillaries:

Microscopic blood vessels are found in the cells of tissues. They have walls made up of single layer of flattened cells called endothelium. Capillary walls are partially permeable that enable substances diffuse readily through it. They are originated from arterioles and branches repeatedly to provide large surface area for the exchange of substances between the blood and the tissue cells.

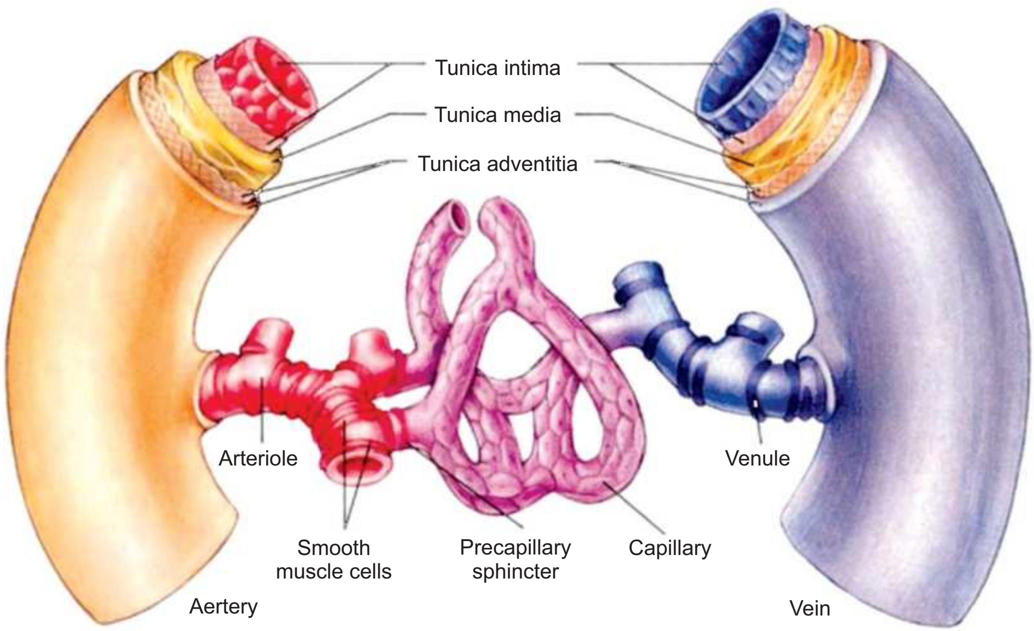


Fig 9.11 Network of blood vessels

Main arteries of the body:

The pulmonary artery which originates from the right ventricle carries deoxygenated blood towards the lungs and aorta which originates from the left ventricle carries oxygenated blood towards the body. Aorta terminates into arteries of the head, neck and arms. Aortic arch curls backward to the left side of the heart and continues downwards as the dorsal aorta, which distributes blood to regions of the body below the heart.

For example, it supplies blood (oxygenated) through hepatic artery to the liver, renal artery to kidney and femoral artery to lower limb.

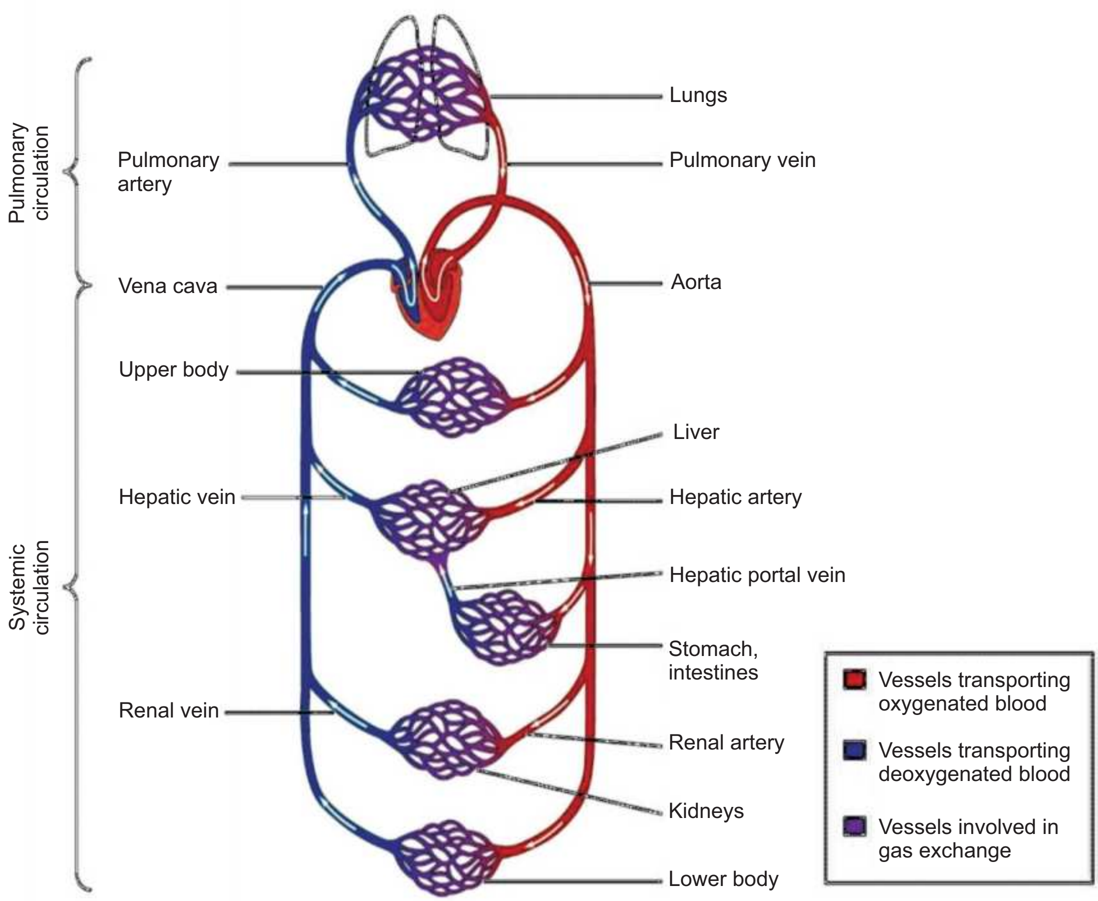


Fig 9.12 Diagram of human circulation

Main veins of the body:

Blood returned to the heart by the main veins as follows:

Pulmonary veins bring oxygenated blood from the lungs to the left atrium of the heart. Inferior vena cava runs upwards parallel to the dorsal aorta and brings deoxygenated blood from the lower body. Among these are renal vein bringing blood from kidneys, hepatic vein bringing blood from the liver and femoral veins bring blood from lower limb to the right atrium. Superior vena cava brings deoxygenated blood from the head, neck and arms to right atrium.

Ibn-al-nafees was the first Arab Physician to explain pulmonary circulation. He believed that all the blood that reached the left ventricle passed through the lungs.

William Harvey was an English Physician to explain systemic circulation in detail. He believed that blood being pumped to the brain and body by the heart.

9.5.4 Cardiovascular disorders (CVD):

Cardiovascular disorders related to cardiovascular system i.e. heart and blood vessels.

In recent days CVD becomes leading cause of death around the world so it is essential to understand them.

Atherosclerosis (ATH): Most common among cardiovascular disease is atherosclerosis (ATH). ATH is a disorder in which bad fats (i.e. low density lipoprotein or LDL and cholesterol) get deposited in blood vessels internal layer.

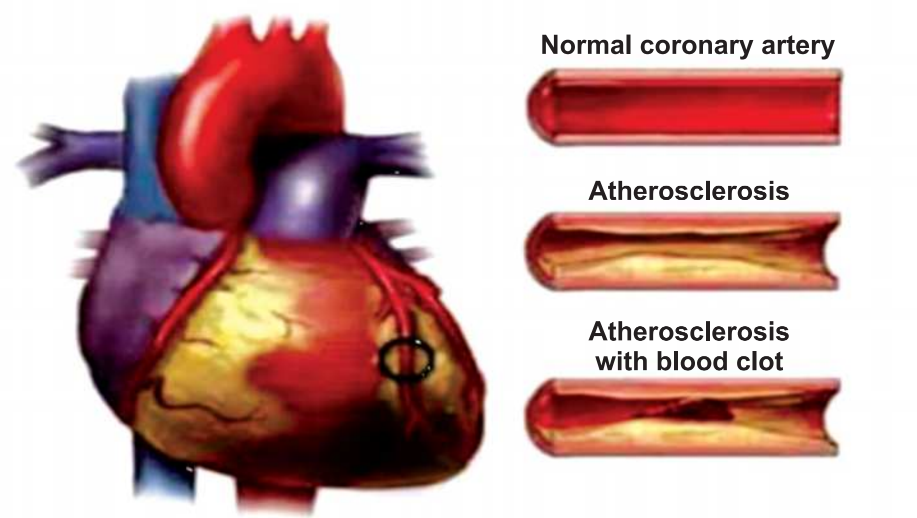


Fig 9.13 Cardiovascular disorders

Accumulation of fats leads to gradual narrowing of lumen of blood vessel. Narrow lumen leads to gradual compromise of blood supply to target organs, and leads to myocardial infarction and stroke.

Arteriosclerosis: It is a process in which arteries loss their elasticity due to some pathological process (e.g. ATH) or simply by aging. Loss of elasticity leads to high blood pressure which may eventually be able to lead to vascular hemorrhage.

Causes of myocardial infarction:

Causes of myocardial infarction can be divided in to non-modifiable factors (which we cannot change) and modifiable factors (which we can change).

Non-modifiable factors	Modifiable factors
Sex (More in males)	Stationary life (no exercise)
Age (More in old age)	Smoking
Race (More in blacks)	Stress
Family history	Heavy alcohol consumption
	High fat diet

Vascular surgery:

Vascular surgery is a prominent field of surgery in which vessels i.e. arteries, veins and lymphatic vessels are managed by vascular surgeons. Field gained very prominence when surgery involves bypass surgeries of heart, angioplasty, and fistula formation in cases of renal failure.

Leading causes of death in Pakistan:

In 2018 cardiovascular disorders (ischemic heart diseases) and stroke (paralysis which is due to damage of brain tissue) becomes major cause of deaths in the world. Stationary life style, poor socioeconomic status, unavailability of state of the art facilities of health, unavailability of doctors in rural areas, lack of health and dietary awareness, etc. all contributed to increase incidence of cardiovascular disorders in our country.

Summary

- Substances required to transfer from one place to another place in an organism requires a system called transport system.
- Autotrophs like plant requires inorganic molecules to synthesize organic molecules. The inorganic molecules transported from environment into them.
- T.S of root shows the internal organization of tissues from epidermis-cortex-endodermis.
- Root absorb H_2O and minerals by two processes:

  (i) Passive transport (ii) Active transport
- The upward movement of H_2O and mineral is called ascent of sap.
- It is the solute in soil should be low for root absorption.
- Loss of internal water of plant in the form of vapours from aerial part of plant called transpiration.
- Surface area of leaf is important for rate of transpiration due to presence of stomata.
- Stomata are the pores surrounded by two ground cells.
- Temperature, humidity, wind, atmospheric pressure are the factors responsible for the rate of transpiration.
- Flowering plant has system of vessels for the transport of water minerals and synthesized food i.e xylem and phloem.
- Xylem made up of four types of cells in flowering plants conducts H_2O and mineral.
- Phloem (Bast) is also made up of four different types of cells conduct synthesized food.
- Unicellular organisms do not require transport system because they remain in contact with environment.
- Multicellular large animals require transport system in the form of circulatory system. Theses are two types; (i) Open circulatory system and (ii) Close circulatory system.

- System where blood flows through spaces among tissues and remain in contact with tissues called open circulatory system.
- System where blood flows in vessels and never come in contact with tissues called close circulatory system.
- Blood is fluid tissue that circulates in body to transport substances.
- Blood has two main parts; (a) Plasma and (b) Corpuscles.
- Corpuscles are R.B.Cs. and W.B.Cs. where as fragments of cells called platelates.
- Leukemia, thalassemia are the blood disorders.
- Heart is major circulatory and muscular pump. In human it consists of four chambers.
- The circulation of blood in the body of man called circuit. There are two circuits in man.
  - (i) Pulmonary circuit; Heart to lungs and lungs to heart.
  - (ii) Systemic circuit; Heart to all body organs and all body organs to heart.
- Pumping of blood by rhythmic pulsation of heart through out the body is called heart beat.
- Phase of heart beat where cardic muscle contract called systolic and where it release diastole.
- Arteries, veins and capillaries are blood vessels required for transport of blood.
- Atherosclerosis, myocardial infection are the vascular disorder.

Review Questions

1. Encircle the correct answer:

(i) The movement of organic materials (food) take place through

(a) Xylem (b) Vessels

(c) Tracheid (d) Phloem

(ii) What regulates the flow of water through the xylem?

(a) Passive transport by the endodermis

(b) The number of companion cells in the phloem

(c) The evaporation of water from the leaves

(d) Active transport by sieve-tube membrane

(iii) Phloem transport of sucrose can be described as going from "source to sink" which of the following would not normally function as a sink?

(a) Mature leaf (b) Storage organ

(c) Growing root (d) Both 'b' and 'c'

(iv) Human plasma proteins include which of the following?

(I) Fibrinogen (II) Haemoglobin (III) Albumin

(a) I only (b) II only (c) I and II (d) I and III

(v) Which of these are involved in the clotting of blood?

(a) Platelets (b) Haemoglobin

(c) Albumin (d) Globulin

(vi) In human heart blood returning from lungs first drains into the

(a) Left atrium (b) Left ventricle

(c) Right atrium (d) Right ventricle

(vii) Root hairs are most important to a plant because they

(a) Store starch (b) Contain xylem tissues

(c) Provide a habitat for nitrogen fixing bacteria

(d) Increase the surface area for absorption.

(viii) A type of circulatory system blood flow through the spaces among tissues called.

(I) Open type circulatory system

(II) Close type circulatory system

(III) Pulmonary circulatory system

(a) I only (b) II only

(c) I and II (d) II and III

(ix) Part of root between epidermis and endodermis called

(a) Xylem (b) Root hair

(c) Phloem (d) Cortex

(x) Movement of water molecules from the area of higher water potential to the area of lower water potential called

(a) Diffusion (b) Osmosis

(c) Active transport (d) Water potential

2. Fill in the blanks:

(i) Loss of internal water of plant in the form of vapours from aerial parts of plants is called________.

(ii) In flowering plants xylem is made up of _________ types of tissues.

(iii) Root hair is long, thin and tubular structure, it increases surface area which increases the ____________.

(iv) Opening and closing of stomata is also regulated by______________.

(v) A type of cancer that affects the blood, bone marrow and lymphatic system called__________.

(vi) Pumping of blood by the rhythmic pulsation of heart throughout the body is called__________.

(vii) Relaxation of heart muscles and allowing the chambers to fill with blood called__________.

(viii) Dead cells of xylem vessels arranged vertically have empty space inside called__________.

(ix) Colourless, irregular in shape, nucleated and larger sized cell than R.B.Cs called_________.

(x) Inherited condition that affects the blood haeomoglobin called________.

3. Define the following terms

(i)	Blood	(ii)	Water potential	(iii)	Diffusion
(iv)	Stomata	(v)	Bifacial leaves	(vi)	Humidity
(vii)	Sieve plates	(viii)	Sink	(ix)	Granulocytes
(x)	Heart beat				

4. Distinguish between the following in tabulated form

(i) Pulmonary circuit and systematic circuit

(ii) Open type circulatory system and close type circulatory system

(iii) Xylem and Phloem (iv) Arteries and Veins

(v) W.B.Cs and R.B.Cs

5. Write short answers of following questions

(i) Why capillaries are made up of single layer of endothelium?

(ii) Why transpiration is necessary for plants?

(iii) How water flow through xylem?

(iv) Why veins contain semilunar valves in it?

(v) Why atherosclerosis cause myocardial infraction and stroke?

6. Write detailed answers of the following questions

(i) Describe structure of human heart with suitable diagram.

(ii) What is blood? Explain composition of blood and function of corpuscles.

(iii) What is transpiration? Explain mechanism of transpiration and factors affecting transpiration.